AUG 1 1 1944

Heating Piping & Air Conditioning

DESIGN
INSTALLATION
OPERATION
MAINTENANCE

AUGUST ★ 1944

INDUSTRIAL
COMMERCIAL
AND LARGE
BUILDINGS

481: *Journal Section of the American Society of Heating and Ventilating Engineers*

Looking down the long back section of the new Boeing wind tunnel, the 24 ft plywood fan and cone shaped hub fairing make an impressive sight

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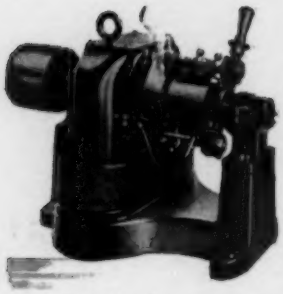
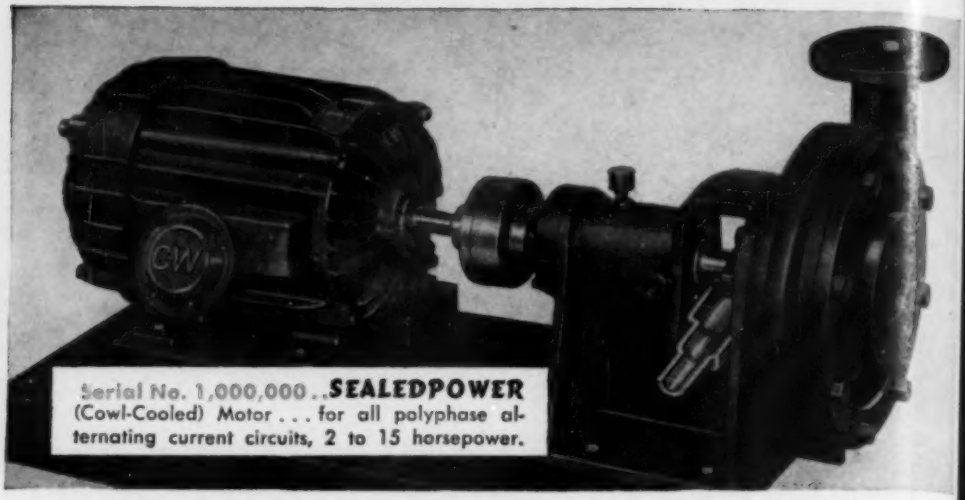


Serial No. 1 . . . Crocker-Wheeler Motor, built in 1888.



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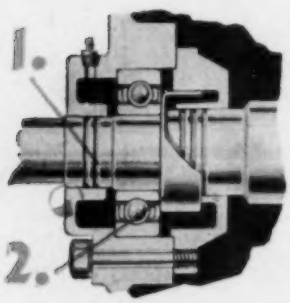

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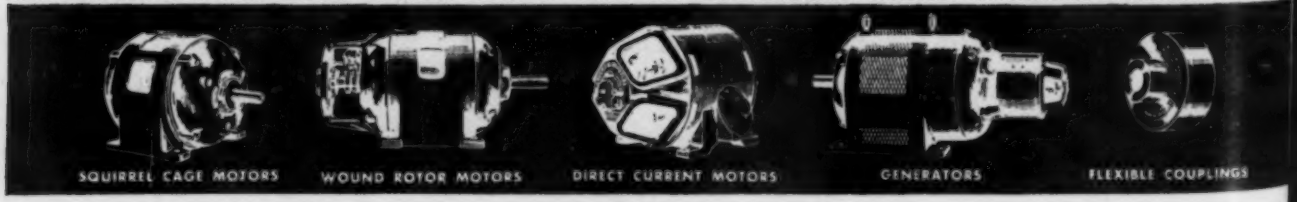

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Heating Piping & Air Conditioning

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Publisher
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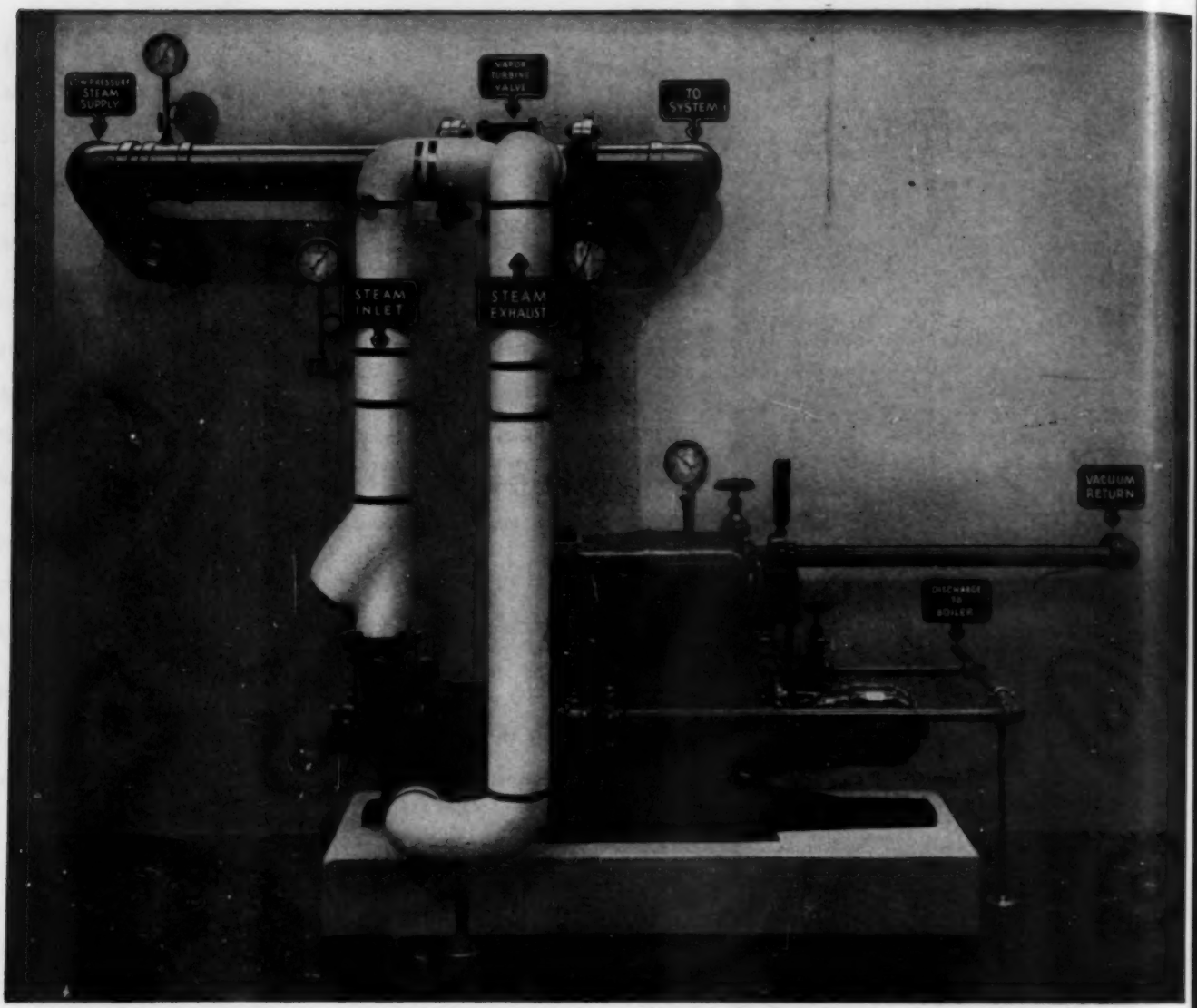
Interrupted Electric Service will not stop this NASH Heating Pump!



In Hospitals, Greenhouses, Schools, Public Buildings, Theatres, wherever heating systems must not fail, install the Nash Vapor Turbine, for it is independent of electric current failure, and continues to operate as long as there is steam in the system.

This is because the prime motive power of this economical pump is a special steam turbine, controlled by a unique "Vapor Turbine Valve", which automatically bypasses from the heating main a small portion of steam, the exact amount necessary to develop the power needed to remove the condensate and maintain the required vacuum on the system. Even this small amount is passed immediately back to the mains, and goes on to the system with little heat loss. This pump operates on any system, high or low pressure.

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How to Select
High Pressure, High Temperature
Piping for a Test Stand

Section of a schedule 160 forged steel socket welding fitting showing an acceptable fillet weld, recommended here

"I HAVE a small boiler installation to make," a piping contractor writes, "with the necessary piping for a turbine spin test stand and valve test stand. The maximum steam pressure is 2000 psi at 900 F, and the steam pipe size is to be 1 in. Can you advise me the proper pipe to use, and the proper type and material for the flange joints? The stress due to expansion does not present any problem, as the runs are so short."

Reply by Harvey A. Wagner:

Sufficient information has not been given, particularly with reference to the operating conditions, to enable specification of definite design data. Since the piping is intended for a test stand, it is assumed that the service is intermittent and therefore the piping probably will be subject to rapid temperature changes. Particular attention should be directed to this phase of the problem, since frequent temperature fluctuations increase the difficulty of keeping a flanged joint fluid tight.

Minimum pipe wall thickness (t_m) should be determined in accordance with the requirements of the American Standard Code for Pressure Piping, ASA B31.1-1942, assuming that a stop valve is installed in the steam line at the boiler outlet. The formula as given in par. 122(a) of the code which would be applicable to these conditions is as follows:

$$t_m = \frac{PD}{2S} + C$$

In this case, the maximum pressure P has been given as 2000 psi, and the nominal pipe size has been designated as 1 in., which determines D as 1.315 in. and the constant C as 0.05 in. The only item not accounted for is the allowable stress S, which depends on the material used and the operating temperature.

In normal power plant service for continuous operation at 2000 psi and 900 F, carbon-molybdenum material in accordance with ASTM Specification A206-42T would be considered suitable. This material has satisfactory physical properties at 900 F, is readily weldable, and in normal times is commercially available in the form of pipe, valves, and fittings. Numerous alloys have been developed for high temperature service which could be used, many of which contain considerably higher alloy content than the carbon-moly steel. In addition to being more difficult to secure because of their higher alloy content, however, they also are more expensive than is warranted for this job.

Assuming that seamless carbon-molybdenum material is used, the Code for Pressure Piping (see table 3a of the code) allows a stress of 10,000 psi at 900 F. The minimum thickness required for a 1 in. plain end pipe is therefore:

$$t_m = \frac{2000 \times 1.315}{2 \times 10{,}000} + 0.05$$
$$= 0.1315 + 0.05 = 0.1815 \text{ in.}$$

The nominal thickness (t_n) required, allowing for the usual 12½ per cent underthickness tolerance, is $0.1815 \div 0.875 = 0.207$ in. The next heavier commercial wall thickness available is schedule 160, which has a 0.250 in. wall in the 1 in. size.

The quantity of steam required for the turbine spin test is not stated, but it should be noted that this 1 in. pipe has a hole of only about 0.8 in. diameter. If the steam flow is appreciable, it would be desirable to check the pressure drop to make certain that an adequate flow is available to perform the desired job.

While carbon-molybdenum material would provide the safer material and better installation, it is possible that carbon steel could be

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Harvey A. Wagner, Engineer, Engineering Div., The Detroit Edison Co., Explains Method of Selecting the Pipe Material and Wall Thickness, Flanges, and Welded Joints for a 2000 Psi, 900 F Installation for Testing Turbines and Valves . . . Carbon Steel Pipe Could Be Used for the Service, But Carbon-Molybdenum Pipe Is Recommended

used under certain conditions. If the service is intermittent, so that the material is not subjected to prolonged operation at 900 F, carbon steel pipe could be used as indicated by the following. The allowable stress permitted by the code for seamless grade A or grade B silicon killed carbon steel in accordance with ASTM Specification A106 at 900 F is 5600 psi. Then for plain end pipe,

$$t_m = \frac{2000 \times 1.315}{2 \times 5600} + 0.05$$
$$= 0.235 + 0.05 = 0.285 \text{ in.}$$

$$t_n = \frac{0.285}{0.875} = 0.326 \text{ in.}$$

The next heavier commercial thickness available is double extra strong, which has a wall thickness of 0.358 in. for the 1 in. size. The inside diameter of this pipe is only about 0.6 in., which again should be checked to determine whether steam flow will be adequate.

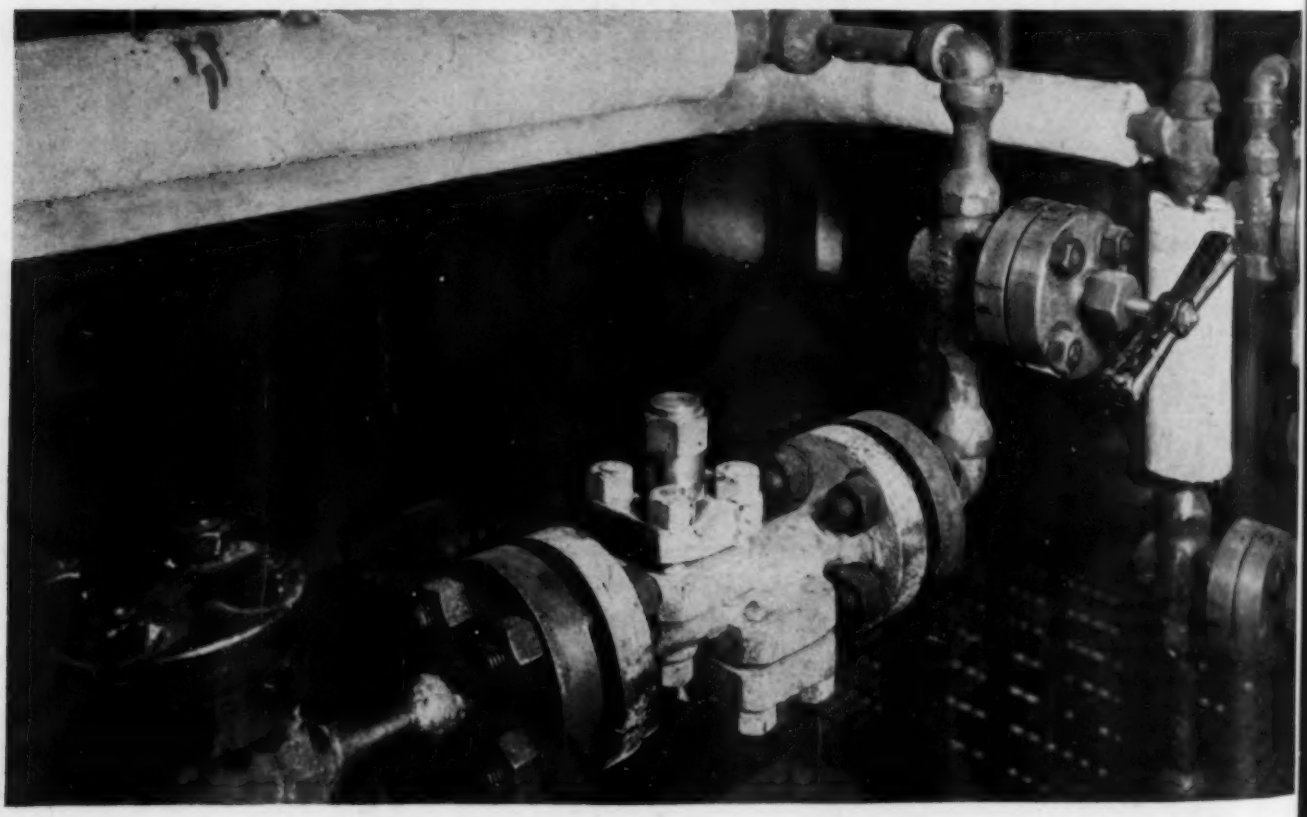
Carbon steel may graphitize when used for continuous steam service at 900 F—that is, iron carbide decomposes to form graphite which in turn provides a zone of weakness that may fail on sudden shock. A temperature of 850 F is considered satisfactory for continuous service for carbon steel. For a valve test stand where no flow is involved, the temperature will not reach the full 900 F except for a short distance close to the boiler. Such a condition would represent the same type of service as for a dead end instrument line which is subject to the full line pressure, but not the full temperature. A special subgroup of the Code for Pressure Piping is considering requirements to cover this situation as it pertains to instrument piping.

Another factor concerns the length of time the installation is intended to function. It takes time for carbon steel to become graphitized at 900 F so that if this installation is of a temporary nature, carbon steel pipe could be depended on to serve for some time, particularly if the service is intermittent. Carbon steel, even of the double extra strong weight, would cost considerably less than carbon-moly and most likely would be more readily available. Carbon steel pipe should be open hearth seamless in accordance with grade B of ASTM Specification A106, since the service conditions are sufficiently severe to warrant securing the better grade material. It is the recommendation of the writer, however, that carbon-molybdenum pipe in accordance with ASTM Specification A206 be used, if available, because of its greater stability for 900 F service.

Use Welding Wherever Possible

As regards joints, it is difficult to maintain a tight flanged joint using high temperature steam under intermittent service because of the large temperature differentials encountered between the pipe, flanges, and bolting. When the line temperature changes rapidly because of admission of steam to a cold line or because of exhausting the line, the pipe and thin sections of the flange close to the axis of the joint change temperature more quickly than the heavier flange sections or the bolting. Consequently, if the bolts have been tightened too much when cold, the stress attained on heating up may exceed the yield point of the bolting material, or the flanges may be permanently deformed during the heating-up period. On sudden cooling, the pipe and parts of the flange closely associated therewith may cool more rapidly than the bolts, thus reducing the gasket pressure to a point where the joint may leak and permit steam to blow.

Example of socket welding valves and fittings and welding neck flanges used for high pressure, high temperature drip piping



Since this condition is aggravated by collection of condensate at a flanged joint, care should be exercised to properly pitch and drip the line.

For these reasons, it is considered advisable that the line should be designed with a minimum of flanged joints, using welding wherever possible. For the carbon-moly line, schedule 160 carbon-moly socket welding fittings could be used to provide an entirely satisfactory installation. For the carbon steel line, 6000 lb series carbon steel, hydraulic, socket welding fittings intended for use with double extra strong pipe would be acceptable. Socket welding fittings of both carbon and carbon-moly steel are available from several manufacturers. It is recommended that the schedule 160 fittings conform to dimensions of the proposed American Standard for Socket Welding Fittings, ASA B16.11.

Some engineers favor screwed steel fittings seal welded. The threaded joint is intended to give the necessary mechanical strength, whereas the seal weld provides a leakproof joint. Since it is desirable to keep the heat input low so as not to distort the threads unduly, the welder should be familiar with seal welding. Because of the difficulty experienced in avoiding distortion of the threads when seal welding, use of socket welding fittings is preferred.

Ring Type Flange Joint Advised

Where it is essential to include flanged joints, it is suggested that carbon-molybdenum flanges in accordance with the 2500 lb series of the American Standard for Steel Pipe Flanges and Flanged Fittings, ASA B16e, be used. A ring type facing is recommended, using an octagonal type ring of SAE 1020 steel. Experience with this type of joint in an experimental unit at Purdue University indicated that it can be used successfully for pressures up to 3500 psi and temperatures up to 830 F, where conditions of rapidly fluctuating pressure and temperature occur.* Use of carbon-molybdenum material should make this joint satisfactory at 900 F for the conditions prescribed for this line. Even in case carbon steel pipe is used, it would be necessary to provide 2500 lb carbon-molybdenum flanges, since carbon steel flanges are not adequate.

The flange on the end of the pipe should preferably be the welding neck type, butt welded to the end of the pipe. Because of the small pipe opening, no backing ring should be used, but any weld metal which extends into the pipe can be removed from the open flange end. Another possibility is to use a lapped flange joint. In this case, the end of the pipe is lapped over to accommodate a loose flange. This type of joint is inherently less strong than the butt welding type but has the advantage of ease of assembly because the loose ring can be rotated to match the drilling of the mating flange of a valve, for instance.

The choice of bolting for a flanged joint also is important. For the operating conditions specified, the Code for Pressure Piping requires the use of alloy steel bolting. Bolt studs, full threaded in this case, made of grade B14 alloy steel of ASTM Specification A193 are recommended. Nuts should be class 2H of ASTM Specification A194. Under wartime conditions, it may be necessary to use substitutes if the above materials are not available.

In the opinion of the writer, however, flanged joints should be dispensed with insofar as possible in favor of welded joints. It should be noted that in welding carbon-molybdenum pipe and fittings of the thicknesses specified herein, the Code for Pressure Piping requires preheating, but not stress relieving. Neither one would be required for welding the carbon steel recommended herein.

*Piping for 3500 Lb Steam, by H. L. Solberg, Heating, Piping & Air Conditioning, June 1937.

WEATHER CHANGES PRECIPITATE INFANTILE PARALYSIS ATTACKS

While the weather outdoors—but not indoors—is not susceptible to control or regulation by the heating or air conditioning engineer—or by anyone, for that matter—its great effect upon us is a fascinating and very worthwhile study. Much has been done in recent years to apprise engineers of the work along these lines being done by the medical profession, and much has also been done to keep the doctors informed of the results of engineering studies. It is important to the health, comfort, and progress of all of us, and to the advancement of the human race, that these two professions should work ever more closely together.

It is held by one body of medical opinion, for example, that susceptibility to infantile paralysis is due to improper "blood balance." In hot and humid weather, the blood goes to the outside of the body to help cool it. The consequent reduction in the amount of blood in the organs of the body makes the organs more likely to infection. On this basis, if a person keeps "cool and comfortable," he is less likely to become a victim of infantile.

In medical terms, Dr. William F. Petersen—widely known for his studies of the effect of weather on man—puts it as follows: "Any wide fluctuation of the vascularization of the central nervous system apparently plays a role in the initiation of the attack when the virus is present."

Older clinicians have noted for many years that exposure to cold is a common antecedent. DeRudder and Petersen observed such precipitation of the disease in a group of boys after violent exercise. In the summer, such chilling even (or rather, especially) when the child has perspired, is of significance, according to Dr. Petersen.

Some 10 years ago Dr. Petersen showed that the onset of disease was precipitated when a polar air mass swept over the country. One city after another that was in the pathway of such a cold air mass revealed a precipitation of cases.

Quoting Dr. Petersen, "Presumably the virus is rather widely disseminated in the population at large and then sudden demand for vasomotor adjustment, with regions of partial anoxia in certain areas of the central nervous system, particularly the cord, apparently leaves the tissue more susceptible (or possibly adhesive for the localization of virus) and symptoms follow promptly."

Sam Lewis' Page

In this regular feature, informal comment on heating, piping, and air conditioning problems and their solutions is given — at the request of the editors — by Samuel R. Lewis, consulting engineer, and a member of HPAC's board of consulting and contributing editors

A SUBSCRIBER in New York asks: "Do school classrooms, in which only reading, mathematics and similar subjects are taught, require mechanical ventilation when there are 36 pupils in a room that is 23 ft deep, 35 ft long, and 12 ft high with exterior window area equal to 20 per cent of the floor area?"

He goes further to quote from the New York City municipal code covering ventilation, to the effect that the state law which requires mechanical ventilation in school building classrooms does not apply to these classrooms in New York City, but that the New York City schools come under the municipal code. The ultimate effect, however, is to require mechanical ventilation in classrooms unless the rooms have a very large percentage of outside wall broken up by masonry window openings.

The code requires that:

"Spaces above grade designed for human occupancy, with windows shall have ventilation either from windows or from mechanical means, or from both, in accordance with the following index and requirements:

"Contents per person in cubic feet, plus ten times floor area per person in square feet, plus one hundred times the entire masonry window openings per person in square feet equals index.

"Air must be supplied and exhausted as follows:

Index	*Supply*	*Exhaust*
520-859	1½ cfm per sq ft of floor	1½ cfm per sq ft of floor
850-1650	No requirement	1 cfm per sq ft of floor
1650 and higher	No requirement	

The foregoing minimum volumes must be increased if excessive heat or objectionable gases are present, in which case sufficient ventilation must be provided to prevent harm to the occupants."

Our correspondent computes the index for the classroom example in his question as 939, suggesting that if the classroom is in New York City the legal requirement would be satisfied if 1 cfm per sq ft of floor is exhausted from the classroom.

The New York compulsory ventilation law for school buildings originally authorized the commissioner of education to determine the requirements for proper ventilation of school buildings. This law has been repealed. The repealed rules required, among other things, that the supply of air by mechanical means should be not less than 30 cfm per pupil in public school classrooms.

The adoption in many of the states of laws requiring mechanical ventilation in public school classrooms was brought about by intolerable conditions as to temperature and air distribution. The usual classroom, heated by direct radiators and providing only by windows such ventilation as was obtainable, caused drafts and overheating for the pupils in their fixed seats along the outer walls, while the pupils more distant from the radiators and windows suffered.

The early rules, requiring that all of the 30 cfm of air per pupil must come from outdoors and must be thrown away at 70 F, generally have been modified. It has been fairly well proved that the delivery into the classroom of so much new air from outdoors is excessive, and that the operating cost for conditioning this large volume is unnecessary. It has been proved, however, that if less than about 30 cfm of air per pupil is delivered into the room or is consistently circulated within the room, there will be difficulty in preventing too rapid and too wide swings of temperature and relative humidity. The bodily heat and moisture given off by 36 to 40 pupils act as a flywheel to bring the temperature above 70 F after steam is shut off.

Solar heat reception (or its absence) through windows and walls also complicates the temperature control problem. Thus the ventilating system must be ready to remove the surplus heat quickly, or to supply additional heat, and the old rule of 30 cfm of air moved among the pupils proves excellent. The chemical condition of the air delivered generally is acceptable, and is safe enough as to odors, if only about one-third of the 30 cfm is taken from outside, with 20 cfm being recirculated.

Regardless of the kind of heat carrier, such as steam or water, in the radiators and regardless of whether the air is warmed in a central plant serving many rooms or is warmed in a fan-equipped convector in each room, the best experience as of today suggests that there should be no reduction in the 30 cfm volume of air per pupil to be delivered around his body.

The state education department at Albany reports on June 9, 1944 that statutory requirements covering school ventilation have been repealed. The old statutory requirements did *not* apply to New York City public schools.

No one has asked me what I would do about it, but were I the boss I'd require provision for introduction during occupancy of at least 10 cfm per pupil in classrooms, this volume being mixed and distributed along with at least 20 cfm per pupil of recirculated air. I'd require arrangements whereby the 30 cfm per pupil could be recirculated when heating prior to occupancy, and whereby all of it could be taken from outdoors in mild weather. In writing a code, I'd make the requirement "per square foot of floor area per minute" so as to cut through complicated indices such as that quoted.

Design and Control of year 'round comfort Air Conditioning Systems

No HARM will be done if occasionally some moisture from the return air condenses on the secondary coil. In fact, this is likely to happen occasionally and for this reason drain pans and piping should be provided for the secondary coils. When condensation of moisture on the secondary coil does occur, the conditioned rooms will be maintained at a lower humidity than is actually necessary for comfort.

Water Temperature for Secondary Air Cooling Coils

Condensation of moisture on the secondary coil results in an unnecessary increase in refrigerating load which can be avoided by supplying the chilled water at a high enough temperature. To prevent condensation on a secondary coil, the lowest initial temperature at which the refrigerant may be supplied can be computed from the following formula. [This formula is obtained from equation 5 of appendix 7 of the article on page 159 of the March 1939 issue of HPAC.]

$$t_R = t_1'' - \frac{Bf_s}{f_R}(t_2 - t_1'') \quad \ldots\ldots [4]$$

where t_R = initial temperature of refrigerant supplied to the coil; t_1'' = initial dew point temperature of secondary air entering coil (if no condensation occurs, this, of course, is the same as the dew point temperature of the air leaving the coil); t_2 = dry bulb temperature of the air leaving the secondary coil; B = ratio of external to internal surface of the coil; f_s = coefficient of heat transfer through air film, Btu per hr per deg per sq ft of external surface; and f_R = coefficient of heat transfer through refrigerant film inside of coil, Btu per hr per deg per sq ft of internal surface.

If the temperature of the refrigerant supplied to the secondary coil is to be held constant all through the air conditioning season, then, of course, the initial temperature of the refrigerant must be based upon the lowest dry bulb temperature and dew point temperature that is to be maintained in the conditioned room. Generally as the outside temperature falls, the internal dry bulb temperature will be allowed to fall to 72 F. If the temperature of the refrigerant to the secondary coil is based upon a room dry bulb temperature of 72 F and its associated dew point, obviously the refrigerant will be too cold when the room temperature is maintained at 80 F, and condensation is likely to occur on the secondary coil. Thus, under maximum load conditions too large a percentage of the refrigerating capacity may be devoted to the latent load. For this reason when using a primary air system, it is desirable to vary the temperature of the refrigerant supplied to the secondary coil with the outdoor temperature. Two desirable aims can be accomplished by varying the water temperature with the outdoor temperature. In the first place, some control can be obtained over the indoor dry bulb temperature so that the occupants cannot maintain too low an indoor temperature if the outdoor temperature rises. In the second place, condensation of moisture on the secondary coil can be kept to a minimum so that the proper proportion of the refrigerating capacity will be devoted to maintaining the dry bulb temperature of the room under maximum load conditions.

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Quotient Rule for Temperature Difference

After the secondary coil has been selected for one set of conditions, its performance under any other set of conditions can be figured quite simply by means of the rule given below. For any given *dry* surface coil with a given quantity of water and air flowing through the coil:

The quotient obtained by dividing the temperature change of the air by the initial temperature difference is always a constant.

The initial temperature difference is, of course, the difference between the dry bulb temperature of the air entering the coil and the temperature of the water entering the coil. Thus if the coil has been selected to cool the air from 80 deg to 64 deg when the water is supplied at a temperature of 59 deg, the constant quotient is $(80 - 64)/(80 - 59) = 16/21 = 0.76$ deg, the temperature change of the air per degree initial temperature difference.

Now if the air is to be cooled from, say, 72 deg to 57 deg, the initial temperature of the water required can be found as follows:

Temperature change of air $= 72 - 57 = 15$ deg.

Initial temperature difference required $= 15/0.76 = 20$ deg.

Initial temperature of water required $= 72 - 20 = 52$ deg.

It is also necessary to check the required initial temperature of the

water under the new conditions to determine whether or not condensation will occur. For this purpose equation 4 is used. If the temperature computed by means of equation 4 is higher than the 52 F temperature just determined by the quotient rule, no condensation of moisture will occur on the coil. On the other hand, if the temperature determined from equation 4 is lower, condensation of moisture will occur on the coil for a 72 F room temperature. If the total refrigerating load for the 72 F room temperature is low enough so that a 72 F room temperature can be maintained in spite of the extra refrigerating capacity required for the extra dehumidification, some condensation of moisture on the coil at the lower room temperature may not matter. The only adverse result will be that the operating cost will be increased because of the extra dehumidification. On the other hand, if condensation is to be avoided, then it will be necessary to select another coil such that, under all conditions from 72 F to 80 F room dry bulb temperature, the required temperature of the water supplied to the secondary coil will be equal to or slightly above the temperature determined by means of equation 4.

Determining Water Temperature for Heating

The quotient rule can also be used to determine the temperature of the hot water to be supplied to the coil when it is used for heating the air instead of cooling it. Thus, suppose that the heat load of the room is such that the secondary air must be heated from 72 F to 113 F to maintain the required heat in the conditioned space in the winter. At what temperature must the warm water be supplied to the coil? This can be figured by means of the quotient rule as follows:

Temperature change of air = 113 − 72 = 41 deg.

Initial temperature difference required = 41/0.76 = 54 deg.

Initial temperature of water = 72 + 54 = 126 deg.

The quotient rule is quite versatile in its application to dry surface coils and can be used to figure the coil performance and the temperature of the water required under a great variety of heating and cooling conditions as long as no moisture is condensed on the surface of the coil and the quantities of air and water circulated through the coil remain the same.

Varying Dew Point Temperature of Primary Air

It is desirable for the dew point temperature of the primary air supply to vary with the outdoor temperature. As will be made apparent in a later section, an outdoor thermostat is not always necessary to accomplish this purpose. If the dew point temperature of the primary air supply is maintained constant at the point needed to maintain, say, 50 per cent relative humidity when the indoor temperature is 80 F, this dew point will be too high when the indoor temperature is lowered to 72 F. On the other hand, a primary air dew point constantly maintained at a low enough point for a 72 F room will require extra refrigerating capacity when the room is maintained at 80 F. For these reasons, variation in the dew point temperature of the primary air with outdoor temperature is desirable.

If a direct expansion primary air coil is used, the suction temperature will automatically drop as the temperature of the air entering the coil falls. Consequently, the dew point temperature of the primary air supply will be lowered as the outdoor temperature falls without any need for automatic control. The relationship is not an exact one, but if both the high and low required dew point temperatures have been considered in the selection of the coil, satisfactory results can be obtained without any control from an outdoor thermostat. The variation in the dew point of the primary air supply with outdoor temperature should be considered in the design if a system satisfactory for all outdoor temperatures is to be obtained.

Designing Primary Air Systems for Spring and Fall

During the in-between seasons of spring and fall when the outdoor temperature ranges between 50 and 70 F, it is frequently necessary to cool some rooms while others are being heated at the same time. In buildings in which there is no objection to opening windows during these seasons, no problem is presented. By circulating warm water to the secondary coils, heat can be provided whenever the outdoor temperature falls to about 65 or 60 F, as in ordinary heating systems. In this case if the primary air is still supplied at low temperature, there will still be a small amount of cooling capacity available whenever the supply of warm water to the secondary coil is cut off either by the thermostat or manually. As previously shown,

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FUNDAMENTALS

The basic principles that govern the design and control of year 'round conditioning systems are organized and discussed in the series of articles of which this is the sixth, and which is devoted to water temperature for secondary air cooling coils, dew point temperature of the primary air, and designing primary air systems for spring and fall operation. No attempt is made in these articles to show a collection of control and equipment arrangements except insofar as they are needed to illustrate the various points discussed. Instead, the methods of accomplishing certain desired results in air conditioning systems and the broad basic principles that govern the applicability of different types of conditioning systems and controls are presented from a refreshingly new viewpoint. Those who are now designing and will be designing comfort air conditioning systems for postwar installation will find this discussion timely and practical, for no matter what the developments of the future, basic principles will always govern. Mr. Goodman is consulting engineer for the Trane Co., and a member of HPAC's board of consulting and contributing editors.

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when the secondary air is neither heated nor cooled, the mixture of primary and return air is supplied in condition *9* of Fig. 15 [see page 409, July HPAC]. In this state the air supply can still absorb roughly about 25 per cent of the maximum sensible heat load. If the primary air cannot provide sufficient cooling, a window can, of course, be opened.

There are, however, many buildings where, because of outside noise and dirt, air conditioning systems are installed so that it will never be necessary to open a window the year around. In such cases, a special cycle of operation must be provided for the in-between seasons of spring and fall if satisfactory results are to be obtained. As previously stated, during the in-between seasons, some rooms must be heated while others are cooled. This simultaneous heating and cooling can be accomplished quite simply by reheating the dehumidified primary air and cooling only the secondary air. In those rooms in which heat is needed, the thermostat will, of course, cut off the supply of refrigerant to the secondary coil and the small amount of warm primary air will provide sufficient heat for mild weather heating.

In those rooms in which cooling is required, the secondary coil will remove not only the sensible heat load of the room but will, in addition, remove the small amount of sensible heat added by the primary air. The warm primary air will, of course, reduce the sensible heat absorbing capacity of the secondary air supply. To keep the sensible heat absorbing capacity of the secondary air as large as possible, the temperature of the primary air should be varied with the outdoor temperature. As the outdoor temperature drops, the temperature of the primary air supply can be raised. In this manner, the sensible heat absorbing capacity of the secondary air can be maintained as large as possible. Under the circumstances, a reduction in the sensible heat absorbing capacity of the secondary air with falling outdoor temperature does not matter in the type of installations for which primary air systems are adaptable—that is, for offices, apartments, and hotel guest rooms. The reason is, of course, that as the outdoor temperature falls, the maximum sensible heat load that is likely to occur also constantly decreases.

Fig. 16 shows the fact that the temperature of the primary air should vary with the outdoor temperature, and how the heat absorbing capacity of the secondary air varies. Note that at a 72 F outdoor temperature the primary air is supplied at slightly less than 50 F. As the outdoor temperature falls, the temperature of the primary air is automatically raised until at 50 F outdoors, the primary air is supplied at a temperature of almost 115 F. This temperature is not objectionable as the amount of primary air supplied is very small, seldom amounting to more than one room air change in 30 or 40 min. Note from the dotted line near the top of Fig. 16 that at 72 F outdoor temperature the secondary air can absorb 100 per cent of the maximum sensible heat gain. However, as the outdoor temperature falls, the temperature of the primary air increases. Hence, the sensible heat absorbing capacity of the secondary air decreases until at an outdoor temperature of 50 F, the quantity of sensible heat that can be absorbed is 23 per cent of

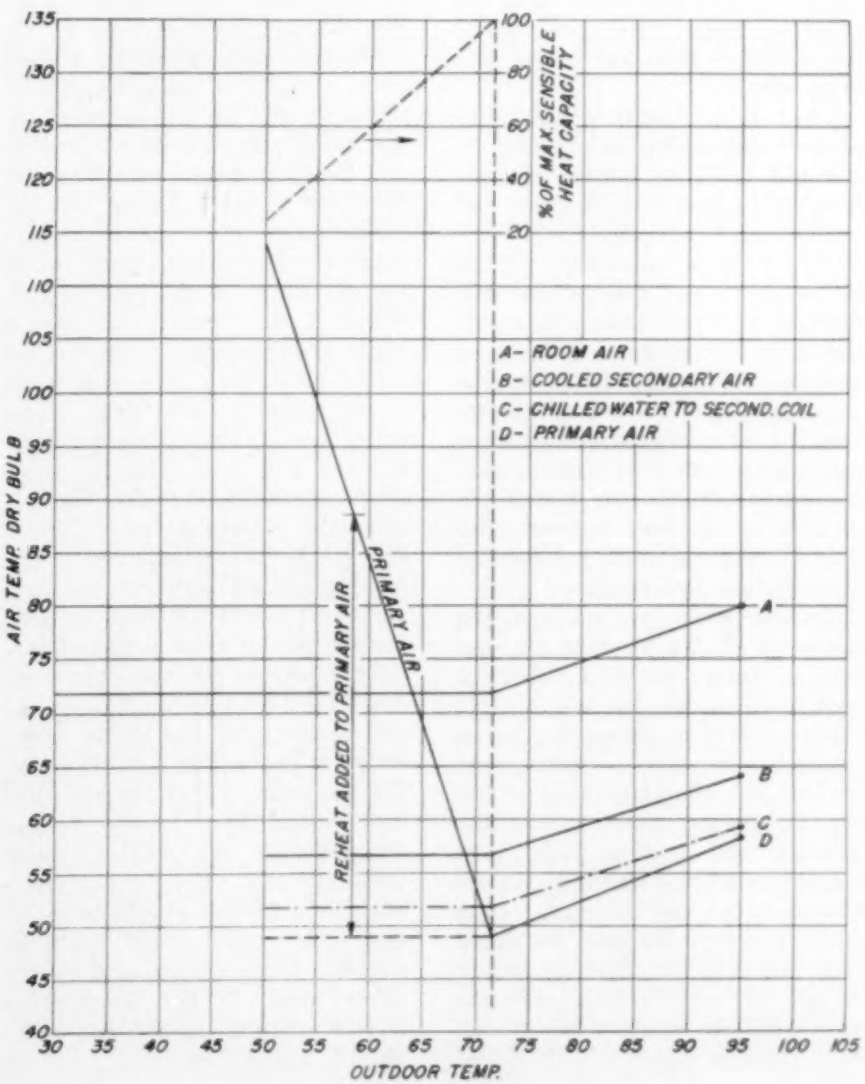


Fig. 16—Chart showing variation with outdoor temperature of the temperatures in different parts of an after-mix primary air system. *Note:* For an actual project, variations in sensible and latent heat loads with room dry bulb temperature should be taken into account in making a temperature schedule chart like the above. Conduction heat gains, and the proportions of sensible and latent heat liberated by people at 72 F would be different from those at 80 F. Though these variations would have a marked effect in many cases, they were not taken into account in this chart, which was prepared for illustrative purposes

the maximum for which the system was designed. As has previously been stated, this is not usually objectionable in installations for which the primary air system is suitable.

Fig. 16 also shows the variation in the temperature of the air leaving the secondary coil and the temperature of the chilled water to be supplied during outdoor temperatures between 72 F and 95 F.

After the outdoor temperature drops below 50 F, the entire system can be changed over to the winter heating cycle with warm water supplied to the secondary coils and the secondary air heated to whatever temperature is needed to maintain the room dry bulb temperature. In this case the primary air should be introduced at a temperature low enough so that when heating is shut off, some cooling of the room will take place if it should be needed. The secondary air must, of course, be heated to a high enough temperature not only to offset the heat losses of the room, but also to reheat the cooler primary air.

There is no way in which satisfactory results can be obtained in a zoned building during the in-between seasons of spring and fall unless both heating and cooling are provided simultaneously. Those zones which need a little heat will be able to obtain it from the primary air. Those zones which need cooling will obtain it from the primary air. This method of providing heat during the in-between seasons by reheating the primary air can be used with either the pre-mix or after-mix systems. [See July HPAC, page 407, for description of these two systems.]

During the in-between cycle, the operation of the primary air system is analogous to a reheating system in which the air is first cooled and then reheated. In an attempt to avoid simultaneous cooling and reheating of air during the in-between seasons, separate heating and cooling coils have sometimes been installed in the air stream supplying the zone. In a pre-mix system the total air would flow through both coils in series. In an after-mix system, only the secondary air would flow through both coils in series. Both chilled water and hot water circulating through separate pipe lines are available simultaneously all through the spring and fall. A thermostat in the return air from the zone or room is supposed to turn on either the heating or cooling coil whichever is needed.

Because duplicate circulating water piping systems and separate heating coils must be provided, this system is more expensive to install than one in which in-between season heating is provided by means of primary air. Theoretically, the method of using separate heating and cooling coils on the secondary air should provide more economical operation in spring and fall. Actually, because of practical considerations described in the next paragraph, the cost of operation is about the same as heating by means of primary air.

As has previously been stated, a thermostat in the return air from the room or zone is supposed to turn on either the heating or cooling coil, whichever is needed. To accomplish such operation, a dead space—that is, a non-operating interval—must be incorporated in the thermostat between the cooling and heating operations. Thus, if the room is being heated and the temperature rises to a certain point, the thermostat should cut off the hot water to the heating coil. Then, if the temperature should begin to fall again, the thermostat would once more open the warm water valve — permitting warm water again to flow into the heating coil and thus raise the room temperature. On the other hand, if after the thermostat was satisfied and the hot water supplied to the heating coil was shut off, the temperature should continue to rise, the thermostat after a rise of perhaps a degree or two—the non-operating interval—would open the cold water valve and admit chilled water to the cooling coil, thus cooling the room. After the room had been cooled back to the desired temperature, the chilled water would be shut off by the thermostat. On a further rise in temperature, cold water would again be supplied to the cooling coil. On the other hand, if the temperature should continue to fall after the chilled water had shut off, the thermostat would again open the warm water valve controlling the flow of water to the heating coil.

Success Depends Upon Temperature Differential

The success of such a system depends entirely upon the temperature differential—that is, the non-operating interval—between the heating and cooling cycles. However, in analyzing the operation of the thermostat it is important to realize that there is a difference between the thermostat differential and the system differential. The system differential is always greater than the thermostat differential. During heating, the temperature of the room air always overshoots past the temperature at which the thermostat shuts off. Similarly on cooling, the room air is always cooled below the temperature at which the thermostat cuts off the cooling. When heating, the ducts are still warm, and the coils are still filled with warm water after the valve on the warm water supply closes. Consequently, the air still continues to heat after the thermostat closes the warm water valve. Similarly, when cooling the air, the ducts are cool and the coil is filled with chilled water after the cold water valve has closed. Consequently the air continues to cool after the thermostat closes the cold water valve. As a result, the differential in a conditioned room—the system differential—is always greater than the thermostat differential for any temperature setting of the thermostat.

After the thermostat cuts off the heating coil, there may be sufficient overheating to cause the thermostat to turn on the cooling coil. Similarly, after the thermostat cuts off the cooling coil because of the continued cooling of the room, the heating coil may come on. As a result of this alternate overheating and undercooling, the heating and cooling coils are continually turned on and off in succession. This alternating operation of the heating and cooling coils can be avoided only if the thermostat is provided with an unsatisfactorily large temperature interval between the heating and cooling cycles.

Because of the limitations of the thermostat, the system of separate

heating and cooling coils in the same air stream operates in the spring and fall in practically the same manner as though simultaneous heating and cooling were provided insofar as operating costs for refrigeration and heating are concerned. However, the control of temperature in the conditioned room with separate heating and cooling coils is not nearly as satisfactory and uniform as it is with simultaneous heating and cooling as in the primary air system using reheating of the primary air during the in-between seasons. Furthermore, it is important to remember that with the primary air system the amount of cooling or heating provided in the in-between weather is small and the cost of either is not likely to be large if a properly designed temperature control system is provided.

Industrial Hygiene in Hot Weather

As High a Ventilation Rate as Feasible Recommended, But Care Must Be Taken to Prevent Solvents and Dust from Escaping Into the Room Atmosphere in Concentrations Above Those Known To Be Safe . . . Unqualified Employees Should Not Tamper With Ventilating Devices

THE HIGH temperatures in summer months bring with them a number of hygienic problems in industry, says the Safety Research Institute, 420 Lexington Ave., New York 17, N. Y., in a recent release. The comfort and health of workers, as well as efficiency in production, depend to a considerable extent on the degree to which hot weather conditions are controlled.

In the hot summer months, a real contribution can be made to the comfort and efficiency of workers by maintaining as high a ventilation rate as feasible, with the rate of air movement within the workroom high enough to cool the occupants by rapid evaporation of their perspiration. Where air conditioning is used in product control, with necessary heat or humidity resulting in damp clothing at the end of the work day, provisions for showers and a change of clothing at the end of the shift are desirable.

In operations involving the use of organic solvents, care must be taken to prevent changes in the ventilation rate from causing the solvent vapors to escape into the workroom atmosphere in concentrations above those known to be safe.

Since many organic solvents are of high volatility, those which may be used safely in cool atmospheres may form excessive concentrations of vapor in hot atmospheres, unless exhausted. Efficient local exhaust ventilation will solve this problem. In operations where the solvent is used intermittently or in small amounts, open windows may provide sufficient ventilation for safety, depending upon the nature of the solvent. However, where local exhaust ventilation is provided for safe use of solvents in tanks, employees generally should not be allowed to open windows; the currents of air thus created may disperse unsafe amounts of vapor into the workroom atmosphere, or if the solvents used are flammable, may increase the hazards of fire and explosion. In such instances, to maintain a comfortable as well as safe workroom atmosphere, general exhaust should be provided, in addition to local exhaust.

Unqualified employees should not be allowed to tamper with ventilating devices provided for safety, or shut them off, as occasionally happens because some individuals prefer the natural ventilation of open windows.

These same rules on ventilation generally apply also where potentially harmful metal fumes, gases, mists, or dusts are controlled.

Industrial dermatitis or skin affections from contact with irritating substances used in industry are more prevalent in the summer months. This problem can be met by minimizing contact with the irritating substance, either by hoods or other mechanical means; by requiring increased personal cleanliness (which implies the supplying of enough washstands or showers, and sufficient hot water and soap); by use of protective clothing impervious to the irritating substance; and by use of protective hand creams.

In plant cafeterias, added care should be observed in the handling and refrigeration of food, and strict attention should be paid to sterilization of dishes and utensils.

Drinking water should be between 40 F and 80 F, preferably around 50 F, says the SFI. Salt and dextrose tablets are placed beside drinking fountains in a number of industries to prevent heat exhaustion, especially where physical exertion and consequent heavy perspiration tend to decrease the normal salt supply of the body.

In both atmospheric and plant sanitation, there are three important steps to be observed: (1) provide ventilation and operating equipment that not only serves its industrial purpose but protects the worker; (2) maintain these facilities in proper condition; and (3) educate workers in the proper use of these facilities, and in the "healthiness" of personal cleanliness.

More complete information on this subject is contained in the Manual of Industrial Hygiene, published by the U. S. Public Health Service, says the SFI.

WARTIME FUEL EFFICIENCY

Burning Coal by Hand Firing

Wartime demands for fuel, transportation shortages, and many other factors mean that we MUST eliminate all possible waste of coal if we are to avoid trouble next winter. Fortunately, there are tremendous opportunities for making fuel savings, one of which is the better firing of boilers in industrial and commercial buildings. . . . Kalman Steiner summarizes in this article the fundamentals of good hand firing, for the problem of fuel conservation must be tackled from the fundamentals. As with the majority of chemical processes, the most satisfactory combustion results are obtained when the raw materials—fuel and air—are accurately mixed in the correct proportions. That condition can only be realized with mechanical firing. Hand firing is efficient only when the theoretical proportions are approached, and Mr. Steiner shows here the methods for approaching the theoretical.

IN CONJUNCTION with the fuel conservation campaign sponsored by the Bureau of Mines of the Department of the Interior, engineers are urged to utilize every conceivable measure that will reduce the consumption of coal. While we have vast resources of coal in this country, the amount available for use is limited by the manpower for bringing it above ground and preparing it for market, the transportation facilities of the railroads, and war demands. The objective of the campaign is to reduce our commercial and industrial annual coal consumption substantially.

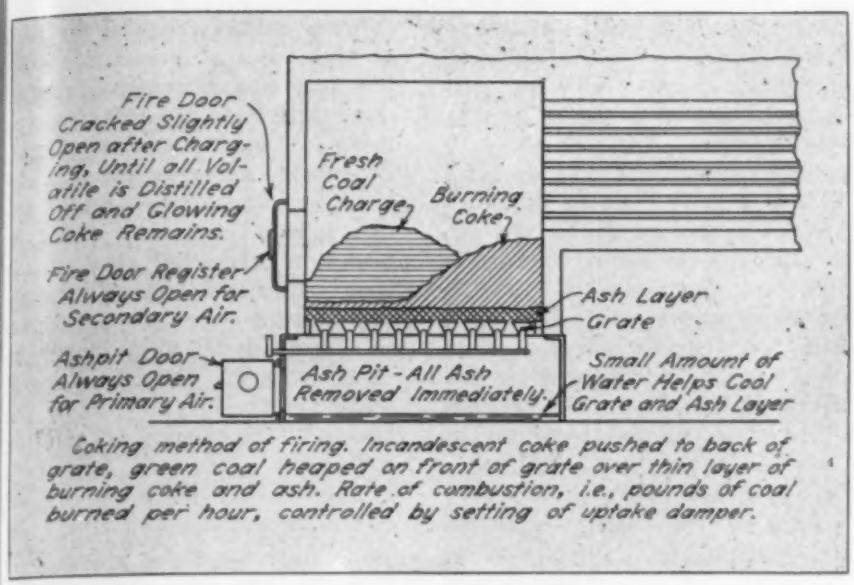
In the belief that the best way to tackle a problem is from the fundamentals, this magazine is presenting a short series of articles dealing with the nature and utilization of coal, embracing sufficient of the technology of coal and combustion to give the operating engineer a clear picture of the factors that enter into economic fuel utilization. The first article, published in June, discussed coal composition and the elements of combustion of coal on grates. This—the second—will elaborate upon hand firing of coal in industrial and commercial heating plants.

It has often been pointed out that combustion is a chemical process involving fuel and air as raw materials. The product of the process is a mixture of gases which escapes through the chimney. In the case of coal there is also a residue of ash. The object of the process is the release of heat. The percentage of CO_2 in, and the temperature of, the flue gases are usually observed as gages of efficiency of the process, although of course an evaporative test is more accurate. As with most chemical processes, the most satisfactory results are obtained when the raw materials are accurately mixed in the correct proportions. That condition can be realized in mechanical firing. Hand firing is efficient only when the theoretical proportions are approached, and it will be the aim here to show the best means of approaching the theoretical with bituminous coal.

It has been shown by the Bureau of Mines that there are four more or less distinct regions in a grate fire: the ash layer on the grate; the oxidizing zone where oxygen of the air stream unites with incandescent coke to form CO_2; the reward through the fuel bed and so

and the fire operated in the manner

Power boilers are generally fired


Fire Door Cracked Slightly Open after Charging, Until all Volatile is Distilled Off and Glowing Coke Remains.
Fresh Coal Charge
Burning Coke
Fire Door Register Always Open for Secondary Air.
Ash Layer
Grate
Ashpit Door Always Open for Primary Air.
Ash Pit - All Ash Removed Immediately.
Small Amount of Water Helps Cool Grate and Ash Layer

Coking method of firing. Incandescent coke pushed to back of grate, green coal heaped on front of grate over thin layer of burning coke and ash. Rate of combustion, i.e., pounds of coal burned per hour, controlled by setting of uptake damper.

ducing zone where the ascending gases have been depleted of oxygen, and the glowing coke reacts with CO_2 to form CO; and the distillation zone, where the volatiles of green coal are expelled. If fresh coal is spread evenly over a hot fire, much of the volatile may fail to burn, but instead will form a dense smoke. The object of successful hand firing is to achieve complete combustion of both the solid matter that remains as coke and the combustible gases that rise from the fuel bed.

There are several recognized methods of successful hand firing. Broadly, these can be classified as low rate combustion and high rate combustion. In general, low rate firing applies to heating plants, where fuel is burned at rates usually not exceeding 20 lb per sq ft of grate per hr. In power plant or high pressure boilers, however, the burning rate is from about 20 lb upward to whatever limits are imposed by available draft. It was brought out in the June HPAC—and is worth repeating—that the rate of combustion is controlled by the supply of primary air, under the grate, and the efficiency of combustion is determined by the supply of secondary air over the fuel bed. While there are variations in methods of hand firing, there can be no deviations from these general rules.

Probably the most widely used type of boiler, other than for domestic heating, is the updraft firebox type, which is made in several designs; for purposes of this discussion, these designs can all be grouped together in the updraft, low combustion rate classification. Authorities are agreed that the most successful firing method is by coking. Fresh coal is charged on to a portion of the grate, either the front or one side, in such manner that the evolved gases are immediately ignited from the glowing coke on the remaining portion of the grate. Secondary air is admitted over the fire, and since the rate of distillation is copious within a few minutes after charging and gradually tapers off, the admission of secondary air must be regulated accordingly. After distillation of the volatiles is completed, the coke is pushed away to be burned on another portion of the grate when a fresh charge of green coal is to be fired.

Cleaning Fuel Bed to Remove Ash

As with all coal firing, the complication in the cycle of the coking method is the cleaning of the fuel bed to remove ash. This should be performed before each firing. By means of the shaking grate most of the ash should be dropped into the ashpit. It is important not to shake live coals through the grate, for by then there will no longer be any ash layer between the grate and the burning fuel. A light layer of ash between the glowing coke and the grate is important for protection of the grate bars from the heat of the fire. (And for additional protection of the grate the ashpit should be cleaned immediately of ash; often a little water is kept in the pit to evaporate and cool the ash layer and grate.) Unburned coal dropped into the ashpit, either by slipping through the bars or shaken through, represents a fuel loss and should be avoided. The grate should be used to clear the fire, therefore, of most of the ash, but a protecting layer must be left there. Any clinker that cannot be shaken through must be pulled from the grate by means of a poker through the fire door.

The fire having been cleaned, most of the incandescent coke is pushed either to the back of the grate, or to one side, but a thin layer is left to prevent the fines of the fresh charge from dropping. In aggravated cases of fines, it may be necessary to dampen the coal before firing to assist in holding them on the grate until they coalesce from the heat. A moderate amount of moisture has one other advantage—in evaporating, this water exerts a cooling effect upon the coal and so retards the evolution of volatile matter, resulting in a slower and more gradual gasification that permits a more uniform mixing with secondary air. The wetting of coal for that purpose is called tempering.

The fresh coal is piled high on the prepared area of the grate, the line of contact between the glowing coke and the green coal being sloped backward, in the case of front to back firing, or toward the pile of coke, in the case of side to side firing. It will generally be necessary to crack the firing door immediately after firing to admit sufficient air for the large volume of volatile matter that is distilled from the fresh coal. A simple test is to open the firing door a few minutes after charging. If the gases burst into flame and had not previously ignited, then more secondary air is needed. As soon as the flame diminishes, the firing door may be closed but the register in it should be left open. The ashpit door is always left wide open. The draft must be regulated by setting the breeching damper according to the load, as discussed below.

In mild weather the entire grate is not needed to carry a straight heating load. A portion should be sealed off with a thick layer of ash,

and the fire operated in the manner just described on the remaining portion of the grate.

Many bituminous coals are caking —that is, upon being heated the coal becomes plastic and then fuses into a continuous mass. This prevents uniform flow of air through the bed, diverting the air into channels, and resulting in blow holes, of which more is said below. To break up the mass in the fuel bed, a slice bar is pushed underneath the surface, preferably in a diagonal direction across the firebox, and the fuel bed gently shaken to break it up. It is important that the fuel bed should not be stirred, for that brings ash up from the grate into the incandescent zone, causing it to fuse into clinker.

The coking method of firing is well suited to the non-fluctuating load of a heating plant. Properly performed, there should be no smoke nuisance. It permits firing at infrequent intervals—several hours, more or less, depending upon load, between firings. As the entire fuel bed is remade with each firing, blow holes are not likely to form or persist in the bed. But it is necessary that some attention be paid to control of secondary air between firings, as the volatiles are consumed, or excess air loss may be high.

The downdraft furnace comprises two grates, an upper and a lower. Commonly, the upper is a water grate, consisting of a bank of water tubes, inclined upward from the boiler front. Fresh coal is charged through upper fire doors on to the upper grate, and air is admitted through the upper firing doors over the upper fuel bed, whence it is drawn downward through the upper fuel bed. That part of the fuel which does not burn completely on the upper grate falls to and is retained on the lower grate until all combustible is consumed, whereupon the residual ash as well as the accumulation of ash which falls from the upper grate is all disposed of through the lower grate to the ashpit or through the lower fire door.

The upper grate of a downdraft furnace is the only case where coal is hand fired more or less uniformly over an entire fire bed. The volatiles in this case are drawn downward through the fuel bed and so are preheated before reaching the combustion chamber. However, just as in the case of the updraft grate, the downdraft grate must be cleaned before fresh coal is added. This is done by running slice bars and pokers through the bed to force ash through the grate. The fire is then smoothed over so that it thickens from front to back, and then fresh coal is placed over its entire area. This thick fuel bed permits long intervals between firings, but the fuel bed must be watched for blow holes. Much can be told of a downdraft fuel bed by looking at the underside of the water grate. Dark areas indicate ash that must be removed; very bright areas result from blow holes that permit much too much air to rush through the fuel bed.

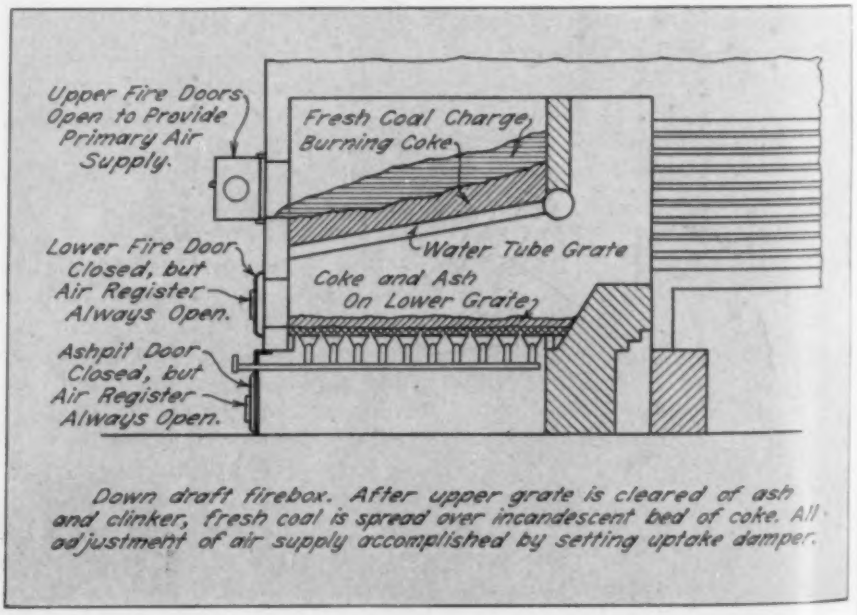
Watch Out for Blow Holes

The air ports on the ashpit doors should be left open, as the air supply upward through the lower grate is needed to consume whatever combustible reaches it, and to complete combustion of the volatiles that are drawn downward from the upper grate. The fuel bed on the lower grate is not thick enough to deplete the oxygen of the ascending air; very little fuel is, in fact, burned on the lower grate. However, it should always be kept covered with enough ash to protect it from the firebox heat, and preferably there should be a layer of burning coke above the ash when the boiler is under load.

Power boilers are generally fired at high rates of combustion with thin fuel beds. Successful firing of these fuel beds requires frequent firing of small amounts of coal. Coal should never be spread at one time over the entire area of the fire. The fresh coal should be placed in only small areas at one time. The method generally recommended is to place the coal over the thin spots in the fire, usually located without difficulty because those are the bright spots in the fuel bed. The primary air entering under the grate will flow more swiftly through the areas of least resistance and so cause more rapid combustion where the bed is thinnest. If these thin spots are not covered with fresh fuel, a blow hole will develop and air will flow through without encountering fuel, resulting in high excess air and low CO_2 in the flue gases. Coal should be fired in about five minute intervals.

An alternate method of operation is strip firing, whereby the grate is considered as a number of longitudinal strips, from two to five in number, and each strip is furnished fresh coal in succession. Still another variation is to fire alternately the front half of one strip, the rear half of the adjacent strip, and so on across the width of the grate, and then to repeat but working on the other series of half strips.

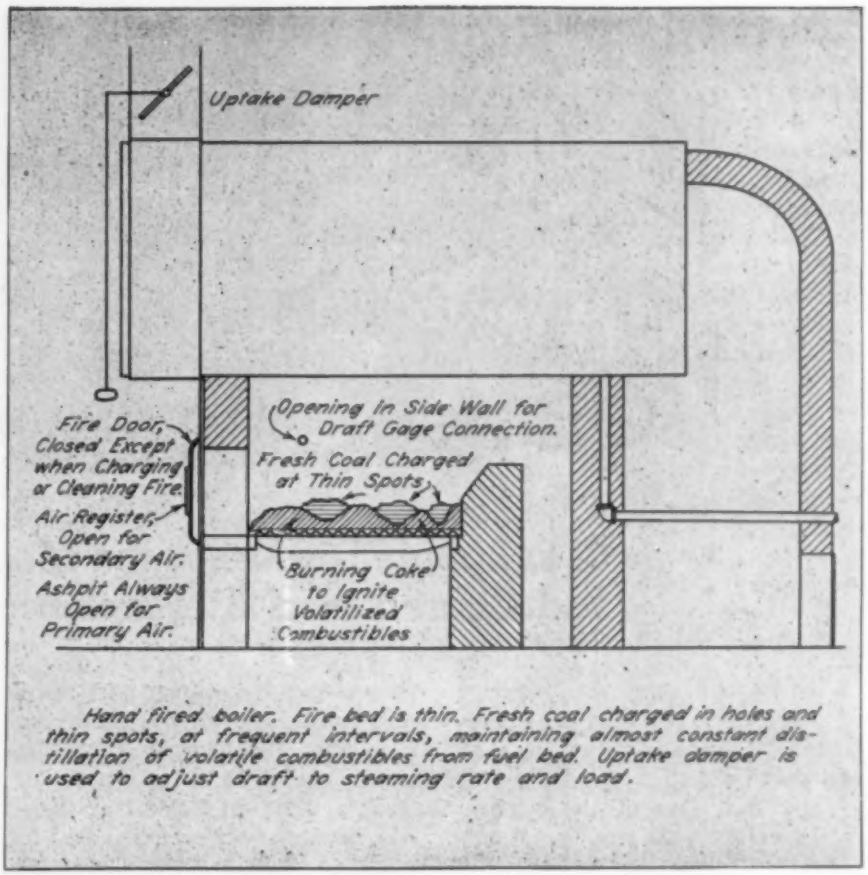
When the fire requires cleaning, i.e., when ash and clinker have accumulated to sufficient depth on the


Upper Fire Doors Open to Provide Primary Air Supply.
Fresh Coal Charge, Burning Coke
Water Tube Grate
Lower Fire Door Closed, but Air Register Always Open.
Coke and Ash On Lower Grate
Ashpit Door Closed, but Air Register Always Open.

Down draft firebox. After upper grate is cleared of ash and clinker, fresh coal is spread over incandescent bed of coke. All adjustment of air supply accomplished by setting uptake damper.

grate, it should be cleaned one-half at a time. The glowing coke is pushed all to one side of the grate, and ash and clinker removed from the other side except for a thin layer of ash that must be left to protect the grate. The fire is then moved to the prepared half and the process repeated to complete the cleaning.

The thin fire method, with its frequent firing periods, brings the supply of fresh coal into approximation to the supply of air. With a constant damper setting, or better yet, with the damper adjusted in conformance to a draft gage to maintain a constant overfire draft, the flow of secondary air is fairly constant, and the frequent firing of small quantities of green coal means the rate of evolution of volatiles is fairly constant also. It is important to maintain a fairly uniform thickness of fuel bed, too, because the resistance through the fuel bed determines the rate of flow of primary air. The maximum available draft will determine the maximum thickness to which the fuel bed can be built up, but a thickness from 4 to 8 in. will be found best. Even though the coal is a caking type and forms a hard crust by fusion, the draft will not be seriously impeded because there will be no large continuous areas of crust to block the flow of gases. The small patches of crust can easily be broken by use of a slice bar, but the precaution must be observed not to stir the fire and so bring ash up into the incandescent zone.


Uptake Damper
Opening in Side Wall for Draft Gage Connection.
Fresh Coal Charged at Thin Spots
Fire Door, Closed Except when Charging or Cleaning Fire.
Air Register, Open for Secondary Air.
Ashpit Always Open for Primary Air.
Burning Coke to Ignite Volatilized Combustibles

Hand fired boiler. Fire bed is thin. Fresh coal charged in holes and thin spots, at frequent intervals, maintaining almost constant distillation of volatile combustibles from fuel bed. Uptake damper is used to adjust draft to steaming rate and load.

Draft Gage a Valuable Firing Tool

One of the most useful instruments in a boiler room is a draft gage. For hand firing it is invaluable. From its readings the fireman can adjust his procedure to secure efficient combustion. Without it, he is working blindly. The only visible evidence of bad firing, other than the draft reading, is smoke. But absence of smoke does not by any means indicate good firing, for tremendous quantities of excess air can be passing through the furnace without giving visible sign. From an orsat test the optimum draft condition for a given installation is readily determined, and the fireman should be instructed as to this draft so he can adjust his dampers to maintain it. Then he can tell when his fire needs cleaning, or when the bed is too thick, or when the coal is packing and caking, for all these increase the resistance through the bed and are reflected by a higher draft reading. The fireman soon learns to control his combustion rate by setting the damper to change the draft reading. The ashpit door should always be left open; to close it endangers the grate bars. The firing door should be opened only for firing or cleaning fires, or, as mentioned above, during the coking stage when that method is used it may be necessary to crack the firedoor just slightly. All other regulation of draft, and therefore of firing rate, is accomplished by setting the uptake damper, and no one can do this properly without a draft gage.

Smoke Prevention and Good Combustion

Another device found very useful in boiler rooms is the steam jet. Originally it was adopted as an anti-smoke measure. But smoke prevention and good combustion are inseparable; efficient operation embodies both. The steam jet, therefore, often assists in raising efficiency; it induces flow of air above the fire, creating a turbulence that brings the volatiles and air into intimate mixture. Furnaces that are short and overloaded are an excellent application of the steam jet. Air jets can also be used for this purpose if there is available an air supply from a fan.

Air and Steam Jets

A very thorough discussion of air and steam jets by Engdahl and Holton will be found in the ASME Transactions for the spring meeting of 1943, and a preprint may be obtained from Bituminous Coal Research Inc., Battelle Memorial Institute, Columbus, Ohio, together with a paper on jet design data. In wartime, when many boilers are being pushed to high overloads to maintain production, the use of a steam or air jet can be of great assistance in attaining high rates of heat release and at the same time avoiding smoke and heavy stack loss.

C. E. Lapple Discusses the Measurement and Character of Atmospheric Pollution

THE MEASUREMENT and character of atmospheric pollution are important to the consideration of mist and dust collection.

Dust fall: One of the common methods for estimating atmospheric pollution is the dust fall measurement. A receptacle is placed above the roof of a building, usually three to four stories high, low enough to be below the average stack level and high enough to reduce the effects of road and street dust. The receptacle is filled with a liquid to prevent the wind from blowing out dust previously collected. The tests are conducted for a period of about a month and the results are generally expressed either as tons of dust per square mile per year, or tons per square mile per month, the area being based on the mouth of the receptacle. Such tests are, of course, very approximate and arbitrary, depending to a large extent on wind conditions and receptacle location, but do serve to give a comparative measure of atmospheric pollution. It should be pointed out that dust fall determinations represent a measure of the coarser particles in the atmosphere only, probably over 1 micron. Details of such measurements are given in references *6*, *7*, *8*, *9*, and *10*. In Table 1 are listed the results of some typical dust fall measurements made in the United States (*6*).

Ringelmann chart: The Ringelmann chart is a device commonly used by municipal smoke abatement agencies for the rapid grading of smoke density from a stack. It consists of a series of six blocks of grids of varying density, ranging from completely white to completely black. A visual comparison of the stack with the blocks of this chart, averaged over a period of time, determines the smoke rating, which is expressed either as the average block number or as an average *percentage density*. For details on the use of the chart, see reference *9*. The conversion of measurements obtained from this test to mass concentration of dust or smoke emitted by the stack would depend largely on the chemical composition, the particle size, the angle and distance from which the stack is viewed, and the general background against which the stack is viewed. This method gives a purely relative visual measurement.

Atmospheric dust concentration measurements: There are four general types of equipment commonly used for dust concentration measurements in atmospheric pollution work: the impinger, the hot wire or thermal precipitator, the alternating current precipitator, and the thimble or filter. In the impinger a measured quantity of dust laden air is passed through an aperture or slit at high velocity and allowed to impinge on a glass plate. The dust, deposited on the plate by virtue of its inertia, is analyzed under the microscope to yield a dust count, which can also be converted to a mass count. The Greenburg-Smith impinger, developed and widely used in the United States, impinges the dust on a glass plate under water and is adapted to sample dust over short or long periods of time. Air is drawn in by means of a hand operated or mechanical pump. The Owens jet dust counter

Table 1—Typical dust fall determinations in the United States[6]

City	Investigator	Location	Year	Average Dust Fall — Total Tons/Sq Mi/Yr	Analysis, Per Cent — Carbon	Ash	Fe_2O_3	Tar
Pittsburgh, Pa.	Mellon Inst.	Whole city	1912-13	1031	31	69	25.3	1.0
Salt Lake City, Utah	Bureau of Mines	Whole city	1919-20	349	35	65	...	..
Grafton, W. Va.	Bureau of Mines	Whole city	1922	1876	46	54	...	..
Cleveland, Ohio	Health Council	Whole city	1927-29	780	29	71	15.4	..
Baltimore, Md.	Health Dept.	Center of city	1926-28	1800	55	45	...	0.5
		3 mi. from center of city	1926-28	800	..	..	...	..
		10 mi. from center of city	1926-28	340	..	..	...	..
Washington, D. C.	U. S. Public Health Service	Whole city	1932-33	291	52	48	5.2	..

is a modified form of impinger, widely used in the United States and England, designed for easy portability and manipulation. A hand operated plunger impinges a grab sample of air on a glass plate through a narrow slit and it cannot be used for continuous sampling or for high dust concentrations. The konimeter, developed and widely used in South Africa, is similar to the Owens jet dust counter except that the air is forced through a circular aperture onto a sticky glass plate by means of a spring loaded plunger. One form of konimeter contains a movable circular glass plate on which numerous samples can be collected in succession. Detailed descriptions of operation and performance are given in references *1*, *2*, *4*, *5*, *6*, and *9*. Reference *10* has a good bibliography.

The thermal precipitator (*5*), largely developed and used in England, utilizes the principle that, in the presence of a hot body, dust particles are repelled and deposited on the cold surface. The alternating current precipitator (*2*, *9*) was developed at the Harvard School of Public Health and is used largely for analysis of smokes and fine fumes rather than dust. It depends for its operation on the electrification of dust particles by a concentrated discharge point and their subsequent migration to a larger receiving surface.

A paper thimble stuffed with cotton (*1*, *2*) through which a measured volume of air is passed is sometimes used to obtain a measure of dust mass concentration. In the Owens automatic air filter (*6*), a definite quantity of air is filtered at regular intervals through a round spot, $\frac{1}{8}$ in. in diameter, on a disk of white filter paper, which is rotated by clockwork. The degree of grayness of the spot is compared with a standard scale of 10 shades, numbered 1, 2, 3, 4, 6, 8, 10, 12, 15, and 20, varying from very light gray, numbered 1, to a very dark gray, numbered 20, to yield a "shade" number. Under specific conditions it has been possible to translate "shade" numbers to particle count or mass concentration by calibration against another type of sampling instrument.

The impingers are limited to a particle size range of about 0.5 to 5 microns. The efficiency of collection of finer particles is very low, while larger particles appear to be shattered or, by virtue of their high inertia, are "left behind" during the rapid acceleration of the high velocity impinging stream. The electrical and thermal precipitators are probably very efficient in collecting particles down to 0.01 micron. The electrical unit is probably not very efficient in collecting particles much larger than 5 microns due to their inertia, while the thermal precipitator is limited to particles finer than 5 microns for mechanical reasons. The filter type unit should be fairly efficient for particles down to 0.2 micron.

Atmospheric pollution data: Probably the most complete and informative study of atmospheric pollution is that of 14 major United States cities in the years 1931-33 reported by Ives (*6*). The average amount of suspended matter in the air during the winter months in the 14 cities studied, as measured by means of the impinger, was found to be 0.22 grains per 1000 cu ft of air, and the average analysis indicated 65 per cent carbonaceous matter, 35 per cent ash, 12 per cent silica, 2 per cent iron oxide, and 14 per cent elemental sulfur. The average shade number was 1.3. The average number of particles per cubic foot of air was found to be 23,000,000, with a median particle size of 0.58 micron based on number frequency, and only a very small percentage of particles larger than 1.5 microns.

The winter months showed about twice as much pollution as the summer months, with a lower pollution on Sundays than on week days. A great variation in atmospheric pollution was found at different times of day, with a minimum at 2 p.m., a maximum at 8 a.m., a low at 3 a.m., and a high at 10 p.m.

Wind velocity was found to have a marked effect on degree of pollution, an increase in velocity being associated with a decrease in pollution. Wind direction also had a marked effect, which depended on local geographical and industrial orientation arrangements. It was also found that, contrary to common beliefs, rain had very little effect on degree of atmospheric pollution.

Davidson (*3*) reported shade measurements made in New York City throughout the year of 1940. The results substantially checked those of Ives. Davidson also found that dust concentration, as measured by the Owens automatic recorder, varied inversely as the square root of wind velocity and showed no trends with temperature or relative humidity.

From a comparison of measurements on weekdays with those on weekends, and of summer with winter pollution measurements, it may be concluded that, while industrial pollution is an appreciable factor, nonindustrial pollution is an even more important factor in the winter, the main source of pollution arising from the combustion of fuel for heating in commercial and residential establishments.

In comparing various measurements of atmospheric pollution, it should be emphasized that the location and method of measurement must be taken into account if serious errors in interpretation are to be avoided.

"Dust is all pervasive, everywhere, on land or sea . . . in all manufacturing processes; in the smoke from our furnaces". The problem of dust and mist control and collection is constantly receiving more attention and prominence, in order to eliminate nuisances, guard health and safety, reduce maintenance of equipment, recover valuable products, etc. . . . Mr. Lapple, of the technical division, engineering department, E. I. du Pont de Nemours & Co., reviewed the purpose of mist and dust control and collection in his article in the July HPAC, and discussed the characteristics of mists and dusts. This month, he writes on the methods of measurement and character of atmospheric pollution.

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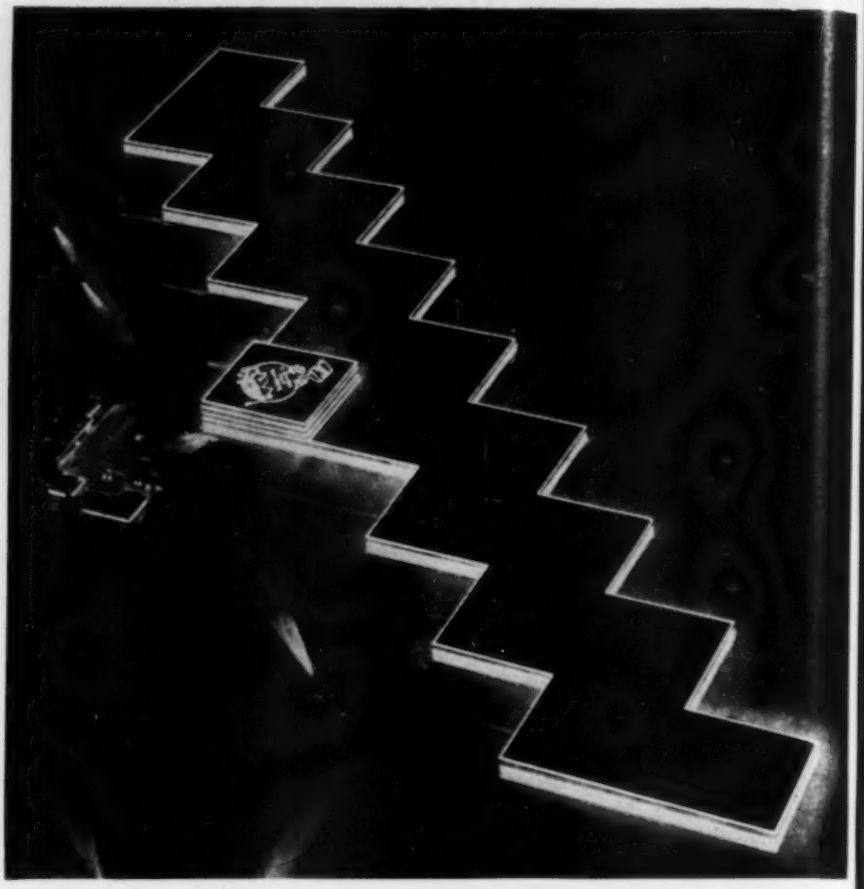
OPTIMISTIC ABOUT ROOM COOLERS

One of the important and fast growing postwar industries is going to be single room, fractional horsepower air conditioners or room coolers, according to Harry Boyd Brown, manager of air conditioning for Philco Corp.

"Undoubtedly the postwar units will be lighter in weight and, therefore, even more easily installed. They will incorporate the new materials and processes that have been developed by war research. Along with all these things, we are planning to make and sell the units at lower prices, which should greatly increase the scope of the market and make them available to many more people than ever before," says Mr. Brown.



"FACTORY OF THE FUTURE"

The "Factory of the Future" will have a definite place in the air age of tomorrow, according to a study by the H. K. Ferguson Co., industrial engineers and builders. As air travel becomes more and more popular, the "air view" will assume increasing importance. Particular emphasis will be placed on this concept by manufacturers of consumer products, who will, in the air age, have the distinct opportunity of presenting in a moment a vivid sales story that can last a lifetime. Night architecture, according to the report, will require new treatment in the design; we have already given negative thought to the problem in the construction of "blackout" war plants, but there is also a positive approach. . . . The interior of the "Factory of the Future" will be "hospital clean," the report continues. There will be clear, wide, unobstructed floor space which lends itself to any adaptations in equipment. Walls and ceilings will be flush. Connections to machines will come from underground service tunnels which also carry piping and conduit. Air conditioning and dust collecting equipment will maintain healthful climatic and atmospheric conditions at all times, with a proper differential between inside and outside temperatures. . . . Lighting techniques will always furnish a topic for discussion in factory planning. A controversial issue is "blackout" plants versus conventional plants with windows. In a few specialized processes, windowless factories are ideal; for average manufacturing and assembly, they are unnatural, according to the report. . . . In discussing boiler houses, the report states that smoke is one of the principal causes for the dreary, dirty industrial fringe around most American cities. The elimination of the boiler house "as we know it today, and the substitution in its place of a source of power and heat which is clean and economical," are predicted. . . . . The layout of any plant should be governed by the function to be performed, according to the study. There are, however, certain fundamental principles that are incorporated in the design of any plant, and there, too, is a "typical" plant for a "typical" industry. The "straight line" production principle has been probably the greatest single influence on design of modern plant facilities. The principle is sound, but all the methods of using the principle have not been explored to the utmost, according to the study.

NDHA HEARS REPORTS ON MANY HEATING AND PIPING PROBLEMS

MEMBERS OF the National District Heating Association assembled recently in Pittsburgh for their 35th annual meeting to hear committee reports and papers on fuel conservation and other wartime problems, and to discuss postwar prospects. A number of the reports, papers, and talks given at the meeting were summarized on pages 421 and 422 of the July HPAC, and the following paragraphs complete the record:

Sizing Condensate Coolers

The commercial relations committee program opened with a paper on sizing economizers and condensate coolers, by Walter A. Schulmeister of the American District Steam Co. It included four charts giving the sq ft of economizer surface required assuming 100 Btu transfer per hr per sq ft per degree mean temperature difference of the liquids with cold water entering respectively at 40 F, 50 F, 60 F, and 70 F, to cool condensate to 80 F, 100 F, and 120 F. He explained that for clean ¾ in. tubes, low friction loss and no baffling, the transfer usually lies between 85 Btu and 110 Btu.

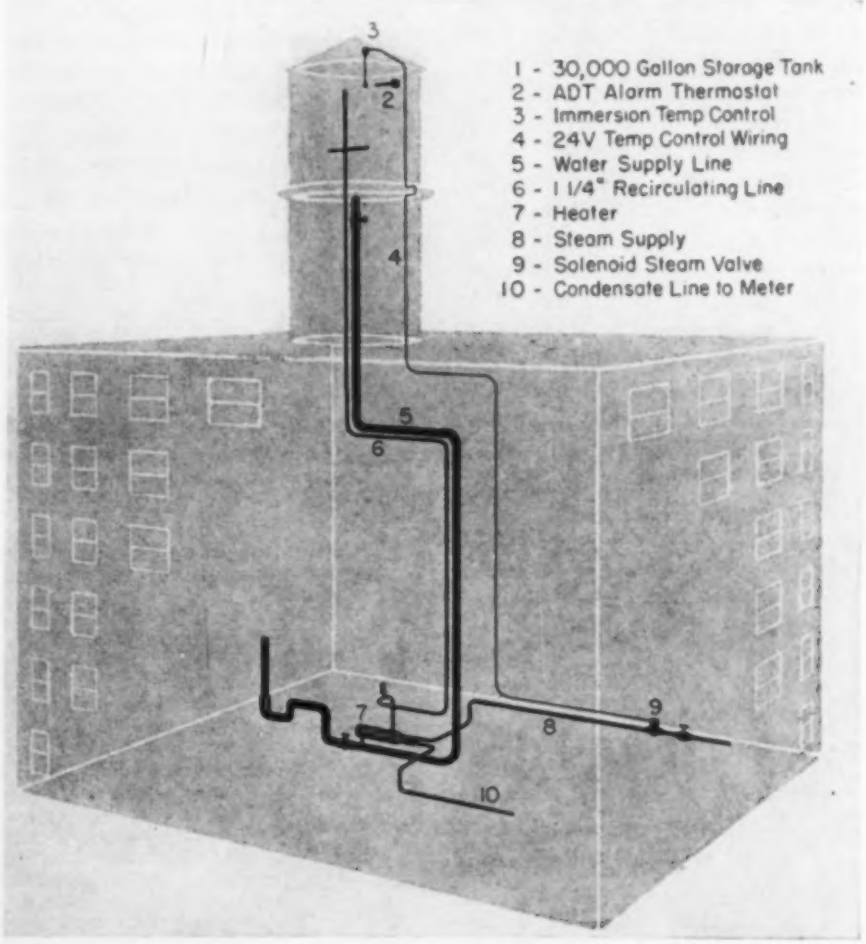
A. F. Metzger, of the steam company in Pittsburgh, in a paper on steam consumption for water heating in various types of buildings, presented a table based on figures submitted by 14 utilities showing the estimated monthly steam use for this purpose in office buildings, department stores, hotels, resident clubs, apartment houses, parking garages and theaters in lb per cu ft per 100 F increase in water temperatures per year with or without economizers. From this table, for buildings having metering facilities to measure only the combined space and water heating steam consumption in the heating season, knowing the summer steam use for water heating alone and the increase in water temperatures, one can estimate the monthly and yearly water heating steam use.

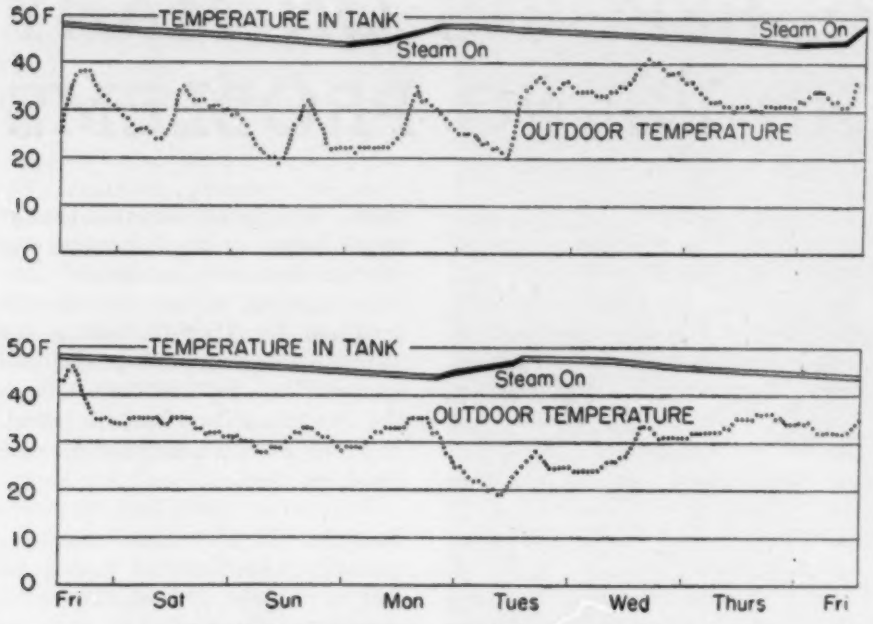
In Detroit a control was installed to prevent water in the sprinkler tank on a building roof from freezing. George H. Tuttle, The Detroit Edison Co., described the system, consisting of an immersion bulb thermostat in the tank, a solenoid valve in the steam supply at its beginning in the basement, and connecting wiring. The control is set to turn steam on when the water drops to 45 F and turn it off when it reaches 50 F. An ADT alarm rings if the system fails, when the water temperature drops to 42 F. [See illustrations.]

The report of the insurance committee, given by Chairman James E. Harris of the Philadelphia Electric Co., covered four subjects—war damage insurance, fire prevention, fire insurance, and fire insurance rates. Mr. Harris said that the interest shown by purchasers of war damage insurance resulted in Congress passing an act waiving the premium for 1944-45, saving the owners of business properties and householders $125,000,000. Since the insurance has been in effect, only one claim of considerable size has been paid.

To prevent fires and eliminate hazards, Mr. Harris recommended periodic inspections of housekeeping conditions and of fire extinguishers. He said that with increased labor and material costs, checks should be made to see that insurance is adequate. He said there were no rate decreases to report except in New York state. He concluded by stating that it is the desire of persons and organ-

Equipment in a dry sprinkler system where the water temperature in the storage tank is automatically controlled


1 - 30,000 Gallon Storage Tank
2 - ADT Alarm Thermostat
3 - Immersion Temp Control
4 - 24V Temp Control Wiring
5 - Water Supply Line
6 - 1 1/4" Recirculating Line
7 - Heater
8 - Steam Supply
9 - Solenoid Steam Valve
10 - Condensate Line to Meter



Correlation between outdoor temperature and water temperatures in the storage tank

izations to purchase a single policy covering all hazards. Some progress is being made in connection with legal difficulties.

T. P. Brown, Jr., New York Steam Corp., chairman of the operating statistics committee, said that his analysis of the more important statistics indicated that, on the whole, district steam companies enjoyed an increase in steam sales in 1943 compared with 1942, due primarily to colder weather, with contributing factors of increased connected load, occupancy, and war activity. Mr. Brown prepared a special supplement to his report which showed for 20 companies reporting for the last 10 yr period an increase in steam sold, an increase in connected radiation, and an increase in cubic feet of space heated. For the companies where the data were available, an increase in distribution system efficiency was noted.

Under the program of the educational committee, Leonard S. Phillips told of the advertising policy changes of his company, the New York Steam Corp., as the war progressed after Pearl Harbor, oil became critical, and the purchase of other materials required priority.

The research committee presented several papers of interest. Chairman A. R. Mumford, Combustion Engineering Co., advised that they had found that the proposed exposed area basis is a much better one for comparison of steam use between classes of buildings and between cities than is the volume basis now in general use and it can be expected to become more accurate and dependable if a factor expressing the hours of heating is included.

In reply to a questionnaire sent out on the subject of steam use for air conditioning, Mr. Mumford said four companies had replied that they had customers using steam for air conditioning—in all 30 customers.

NDHA Secretary-Treasurer John F. Collins, Jr., chairman of the national joint committee on weather statistics, reported that during the year this committee had arrived at several important decisions which would later be submitted to interested societies and associations for ratification. He said they had agreed:

That daily mean temperatures rather than daily average temperatures should be used to compute daily degree days.

That maximum-minimum thermometers rather than thermographs should be used in taking readings of daily maximum and minimum temperatures for degree day purposes.

That the present base temperature of 65 F for degree day computation with normal occupancy is satisfactory.

That normal degree days for any day in the year for any location should be computed by finding the 20 yr average for that day and adjusting as required to produce a smooth curve while maintaining the same total for the month.

He said the U. S. Weather Bureau will supply the normal degree day figure for the 4300 weather stations on the agreed basis when time permits.

In summing up the activities in which the chemistry committee has had an interest, Chairman Leo F. Collins, chemist, The Detroit Edison Co., said that it had been demonstrated rather conclusively that corrosion troubles in heating systems served by district heating companies are in the majority of cases linked up with the effects of carbon dioxide. By proper venting it is possible to prevent the solution of large amounts of CO_2 in the condensate. Thermostatic type air vent valves are not suitable for this use, he said. It appears that a practical vent condenser can be devised. However, condensates with very low CO_2 contents are capable of causing corrosion troubles. Mr. Collins predicted that ultimately boiler water treating methods would be developed, eliminating CO_2, or that chemicals to be added to steam to neutralize the CO_2 would be produced.

Use of Amines

A. A. Berk, associate chemist, fuels and explosive service, U. S. Bureau of Mines, and guest speaker on the chemistry program, agreed with Mr. Collins that carbon dioxide which acidifies the condensate is the chief cause of corrosion of steam heating systems. It was proposed in 1936 that amines—members of a class of compounds in which an organic group is substituted for one or more hydrogen atoms of the ammonia molecule—be used as an alkalizing agent. He said few definite conclusions can be made from the preliminary tests. Others will be run to determine the most economical amine treatment.

First to speak on the program of the steam station engineering committee, under the chairmanship of R. B. Donworth, Allegheny County Steam Heating Co., was Henry F. Hebley, director of research of the Pittsburgh Coal Co. and Pittsburgh district coordinator for the national fuel efficiency program. Mr. Hebley explained the need for fuel economy and the plan agreed on for its accomplishment through the

voluntary service of engineers over the country working with the plant engineers of all but the smaller fuel consumers.

Otto de Lorenzi, director of education, Combustion Engineering Co., explained the methods used in taking colored motion pictures in the study of stoker fuel beds.

The distribution committee program was opened by a discussion of solid pour concrete conduit led by W. W. Stevenson, of the Allegheny County Steam Heating Co. Principal points made were in regard to drainage water and its effect on this type of construction.

A. A. Sellke, supervisor of the underground lines department, The Detroit Edison Co., described the conditions found when 355 ft of a 16 yr old line was replaced because leaks had developed in it. He said among other difficulties the inspection showed conduit cracks permitting leakage, which injured the inner form, impaired the insulation, and corroded the line. The new line and conduit replacing the old incorporates the latest practices.

Mr. Schulmeister, describing the cell concrete insulation installations that have been made in the last decade, said that recent examinations of these jobs show the material has remained stable with no indication of corrosion problems.

The distribution report was concluded by the presentation of a description of a hookup by which a relief valve is used in Dayton to cause condensate to discharge to a sump when steam pressure is too low to raise it to a sewer.

Shortage of labor has caused the steam utilities to reconsider some of their practices in inspecting, testing, and reading meters. Henry L. Warhanek, superintendent of heating of the Wisconsin Electric Power Co., and chairman of the meters and accessories committee, opened the period allotted to that committee with a paper on this subject. He said that a saving in man hours and money had been made without decreasing meter accuracy by increasing the interval between meter inspections and tests and by limiting the scope of the inspections where all appeared in order on observation of registration. Most notable is the practice adopted by some companies of bringing only the condensation meter drum to the shop for testing, leaving the body in place in the line. Routine comparisons of customer consumptions quickly show any meter trouble.

The practice of the company in Rochester, N. Y., of servicing and testing condensation meters after a given amount of condensate has passed through them instead of at regular time intervals was explained by R. H. Brown, Rochester Gas and Electric Corp.

The report was brought to a conclusion by Mr. Warhanek with his presentation of a paper in which he showed that his company had made a saving of 1000 man hours or $1000 by changing from annual meter testing to biennial testing and that by adopting triennial testing the saving would be 1300 man hours or $1300.

Retiring President Julius J. Schenk, in presenting his final report, commented on the activity of the association in fuel conservation and said that it had been operated on sound principles. He pointed out that the utilities were selling more service than ever before.

John F. Collins, Jr., reported the good financial condition of the association and the purchase of U. S. war bonds out of reserve funds. He said that an index of subjects published in the proceedings and bulletin over the past 10 years is well on the way to completion. He said that many technical inquiries are now coming to headquarters for answer. There is a greatly increased interest in district heating not only here but in England. He said it is hoped to have the proceedings of the 35th annual meeting published by September 15.

An increase in association membership was reported by Chairman Joseph M. Barnes, Philadelphia Electric Co. Chairman A. T. Veness, Rochester Gas and Electric Corp., reported numerous revisions to the association constitution being prepared for consideration.

As engineering and technical societies go, the NDHA is comparatively small in membership but its members are intimately concerned with the heating and piping problems in a great number of buildings. The steam utilities very properly take much interest in steam conservation and other heating and piping problems of their customers. The reports and papers given at association meetings are therefore of wide interest not only to district heating companies, but to all concerned with the heating and piping—and air conditioning—of buildings and factories

ASTM APPROVES CHANGES IN STEEL SPECIFICATIONS

Many important changes were approved at the 1944 annual meeting of the American Society for Testing Materials in steel specifications, particularly in the field of pipe and tubing where new marking requirements are being established and modifications in certain physical property requirements are being effected.

Two new specifications covering carbon and alloy steel blooms, billets, and slabs for reforgings were approved for submission to the society during the summer; also four new specifications covering stainless tubing, both ferritic and austenitic grades for general use, for still tubes, and for use in the food and dairy industry.

There was intensive discussion on proposed methods of magnetic particle testing of heavy forgings and castings with a procedure approved for submission to letter ballot involving steel castings, and in the case of heavy forgings further study is to be made to coordinate different thoughts.

Two reports were presented by the ASTM-ASME research committee on the effect of temperature on the properties of metals, the first covering effects of variables on creep resistance of steels and particularly the effect of heat treatment. The other report included a correlation of elevated temperature tests, which indicated that the best correlations were obtained from the sustained load tensile test, the Hatfield time-yield test, and the DIN (DVM) test.

Multi-Room Buildings Pose Air Conditioning Problems of Their Own

One of the greatest postwar markets for complete air conditioning will probably be multi-room buildings, such as hotels, hospitals, office buildings, and perhaps apartments. Such jobs pose problems to the air conditioning engineer which differ from the considerations involved in theaters, shops, stores, and factories, with their comparatively large and open spaces . . . W. L. McGrath, of Carrier Corp., explains here why (to a large extent) the building of 100 to 1000 rooms must be treated as so many individual jobs.

It is becoming increasingly apparent that one of the greatest postwar markets for complete air conditioning may be the large multi-room buildings, including office buildings, hotels, hospitals, and perhaps apartment houses. I am speaking of buildings of possibly 100 to 1000 rooms; to a large extent they must be treated as 100 to 1000 individual jobs, for if we do not give each tenant satisfaction, then the installation as a whole is not satisfactory. The air conditioning engineer's treatment of this problem must be considerably different from his accustomed practice for the commercial establishment, such as the theater, shop, or store, or for the industrial building, with its comparatively large and open spaces.

Let us define the requirements of an air conditioning system that will be satisfactory for multi-room buildings. Our recommendations must provide for the maintenance of comfortable conditions in each individual space 365 days of the year. The familiar definition of the functions of all-year air conditioning includes *ventilation, dehumidifying, humidifying, cooling* and *heating*. To these, let us add *the ability of the system to make heating and cooling available simultaneously, and the ability of the system to maintain each space temperature independently of other spaces.*

Why must the system be able to heat and cool at the same time? Largely because we cannot arbitrarily classify the 365 days which go to make up a year into a "heating season" and a "cooling season." Fig. 3 shows a record of daily temperature variations and daily sunshine records for an east central city of latitude 39 deg. The three lines at the top show, first, those days upon which cooling is required, second, those days on which both cooling and heating are required at the same time, and third, those days upon which heating only is required. These selections were based upon the daily temperature variations and sunshine records. The chart shows very clearly that there are no well defined heating and cooling seasons. It indicates that there were 181 days on which cooling was required, 99 days on which heating was required, and 85 days on which both heating and cooling were required in order to maintain constant conditions in all spaces of an office building.

Further to enable us to realize the problems of control and the problems involved in our so-called "intermediate season" operation, it is convenient to relate all loads affecting the building in terms of equivalent degrees of outside temperature. Fig. 4 shows the hourly variation in sun effect for the west and south exposures of a typical building in Washington, D. C., for the month of June and for the month of December in order to indicate the seasonal variation. It can be seen, for example, that the west zone in the month of December at 5 p.m. has a load corresponding to a 27 F equivalent temperature difference; this means that the building is under the same load condition when the outside temperature is 53 F as it would be at an outside temperature of 80 F were the sun not shining. It is possible to express the loads due to sun effect, internal load, or wall lag for a particular building in terms of degrees of equivalent outside temperature. This can be done as follows:

Equivalent degrees due to sun

$$= \frac{h_s A_g}{U_g A_g + U_w A_w}$$

Equivalent degrees due to internal load

$$= \frac{H_i}{U_g A_g + U_w A_w}$$

Equivalent degrees due to wall lag

$$= \frac{\Delta t_o \times A_w \times f_g}{U_g A_g + U_w A_w}$$

where A_g = glass area, sq ft; U_g = glass transmission factor, Btu per sq ft per hr per F; A_w = wall area,

Fig. 1—The Pentagon building, Washington, D. C., said to be the world's largest office building, is completely air conditioned to keep those directing the nation's war effort working at peak efficiency. Charles S. Leopold was consulting engineer for the air conditioning. Each space is controlled at the proper temperature despite rapidly changing loads

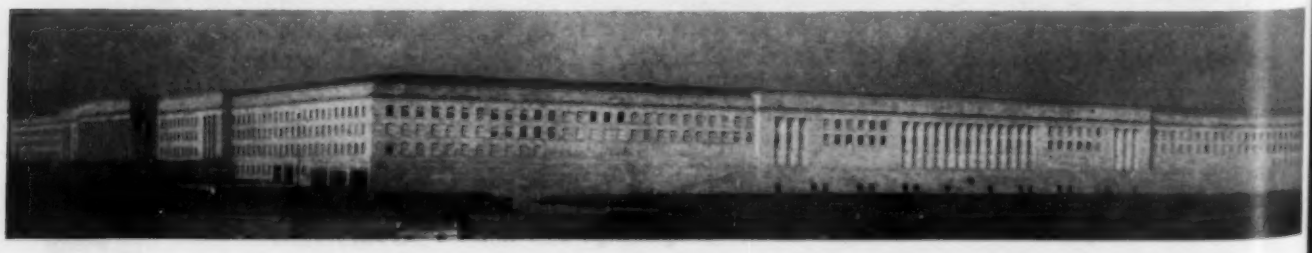


Fig. 2—The Statler hotel, Washington, D. C., for which Holabird & Root were the architects. With the modern air conditioning system selected for this installation, each guest can control the temperature in his room, winter or summer. The conduit distribution of supply air effects a substantial saving in floor space in the building

sq ft; U_w = wall transmission factor, Btu per sq ft per hr per F; h_s = incident sun factor, Btu per hr per sq ft; f_s = inside wall surface factor, Btu per sq ft per hr per F; H_i = internal load, Btu per hr; and Δt_s = degrees variation of inside wall from steady state condition (plus or minus).

We can see from the magnitude of the sun gain that there are many days on which one building zone may require cooling while another zone may require heating. Also, to narrow this down to a single zone on which we may presume that the sun effect can be taken care of by central zoning, we still have the problem of variations in load from space to space; for example, a space with no internal load will require heating at outside temperatures below 70 F. However, if an adjacent space has an internal load which is the equivalent of 10 F of outside temperature differential, it requires cooling down to 60 F outside. Then, between the range of 70 F and 60 F equivalent temperature, that particular zone must have both heating and cooling available for each space.

Further, it can be seen that because the internal load varies from one space to the next, then each space should be separately controllable. It is also true that in dealing with large, multiple room buildings there is frequently a diversity in comfort reactions and individual taste.

Tenants or hotel guests may not like to conform to arbitrarily established temperature levels and the individual room control should be subject to tenant adjustment. This is an important difference between the hotel or rental office building and the commercial building where the occupants must, of necessity, accept an average comfort level.

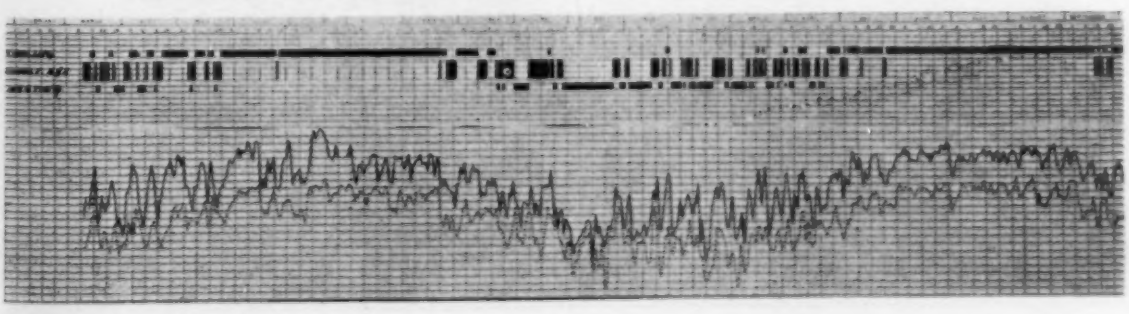
The foregoing discussion applies to buildings which have an external exposure and are subject to large external loads, such as solar heat and changing outside temperatures. Where internal spaces occur, the loads are primarily those resulting from lights and people. Because heating is never required, and because the cooling loads are small as compared to an external zone, the treatment of such spaces is considerably simplified.

Thus, it is well to compare the possible methods of air conditioning a multi-room building on the basis of the capacity for ventilation or odor control, capacity for dehumidifying or controlling latent heat gain, capacity for humidifying or controlling latent heat loss, capacity for cooling and controlling sensible heat gain, capacity for heating and controlling sensible heat loss, capacity for providing cooling and heating simultaneously, and ability to provide individual space control of temperature.

The size of the equipment, supply ducts, etc., is determined by the maximum cooling load. The total quantity of air supplied to a particular space in order to offset the maximum cooling load is determined by the magnitude of the load and the allowable temperature differential which can exist and still avoid discomfort or draft.

Three cases are shown in Fig. 5. In each case the total amount of air to be supplied to the room is determined by the maximum sensible cooling load and temperature differential. In the first case, this total quantity of air is delivered from the central apparatus. Out of the total quantity of air, a relatively small proportion, possibly 20 per cent, would have taken care of all ventilation requirements and the control of latent heat level or room relative humidity; approximately

Fig. 3—The top three lines of this record of daily weather for a period of several months show first, cooling was required for 181 days in a full year, second, that heating and cooling was required for 85 days, and, third, that heating was required for 99 of the days. The two curves in the center show wet and dry bulb temperatures on a scale from—10 F to 100 F



80 per cent of the air supplied must then be returned to the central apparatus through an additional duct system. In view of the quantity of air handled, the velocity in the ducts must be kept comparatively low because of power requirements, distribution requirements, and noise level. Frequently, it will be found desirable to circulate an even larger quantity of air than that indicated by the heat balance in order that the high air change will minimize differences in load from space to space and thereby keep temperature variations at a minimum.

In the second case, we get the same quantity of air into the space at the same temperature differential by locally recirculating approximately half of the total air right in the space. Therefore, the air brought into the space through the supply duct is brought in at a lower temperature and accordingly only about half of the total air considered in the first case need be circulated. Of this total air delivered to the room, approximately 40 per cent would handle the ventilation requirements and provide for the control of relative humidity. With this arrangement, it is again necessary to have a return duct system to return approximately 60 per cent of the air supplied to the room back through the central apparatus. Again it is desirable to keep the velocities low.

In the third case, we again deliver the identical quantity of air at the same temperature differential to the space. Here, however, only 20 per cent of the total is supplied from a central apparatus, the balance of the air being locally recirculated from the space. This air is cooled to the required temperature differential by contact with an extended fin cooling surface carrying chilled water from a central apparatus. Since the amount of air handled is now only 20 per cent of the total, and since good distribution is assured, we can increase its velocity to twice the normal velocity and thus further reduce the size of the supply duct system. Since we are now supplying only the quantity of air required to control ventilation and room relative humidity, this primary air supply comes directly from outside of the building and after being placed in circulation is exhausted and, therefore, not returned to the apparatus. The cooling capacity for offsetting sensible heat load is furnished by relatively small water pipes and the exchange of heat is obtained through the use of water with relatively high density and high specific heat instead of with air of low density and low specific heat.

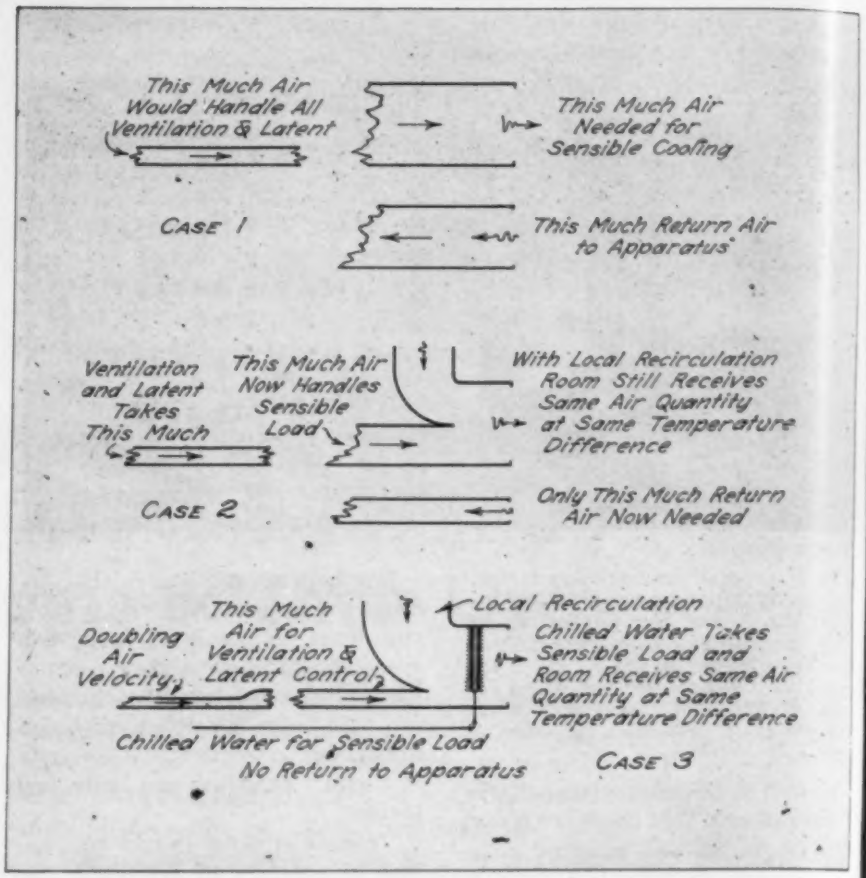
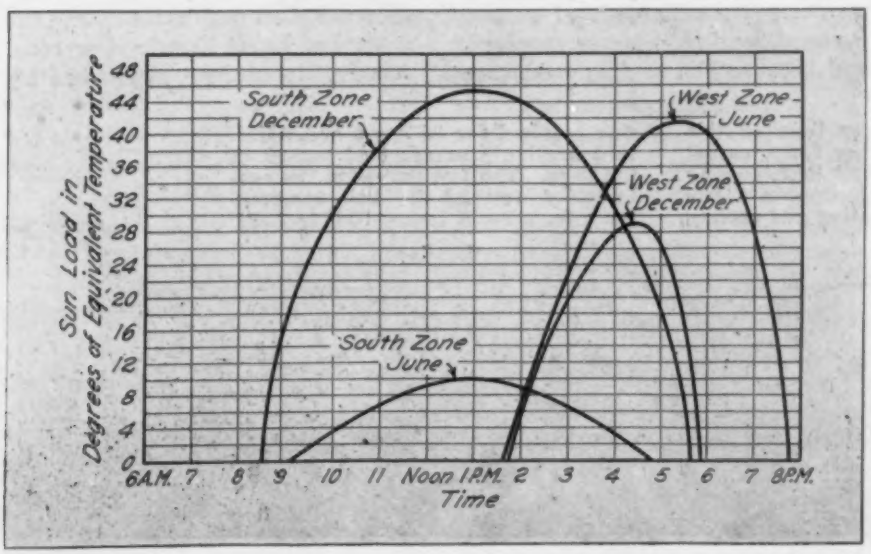

This Much Air Would Handle All Ventilation & Latent
This Much Air Needed for Sensible Cooling
CASE 1
This Much Return Air to Apparatus
Ventilation and Latent Takes This Much
This Much Air Now Handles Sensible Load
With Local Recirculation Room Still Receives Same Air Quantity at Same Temperature Difference
CASE 2
Only This Much Return Air Now Needed
Doubling Air Velocity
This Much Air for Ventilation & Latent Control
Local Recirculation Chilled Water Takes Sensible Load and Room Receives Same Air Quantity at Same Temperature Difference
Chilled Water for Sensible Load
No Return to Apparatus
CASE 3

Fig. 5—Three cases illustrating how different air conditioning designs affect the air handled

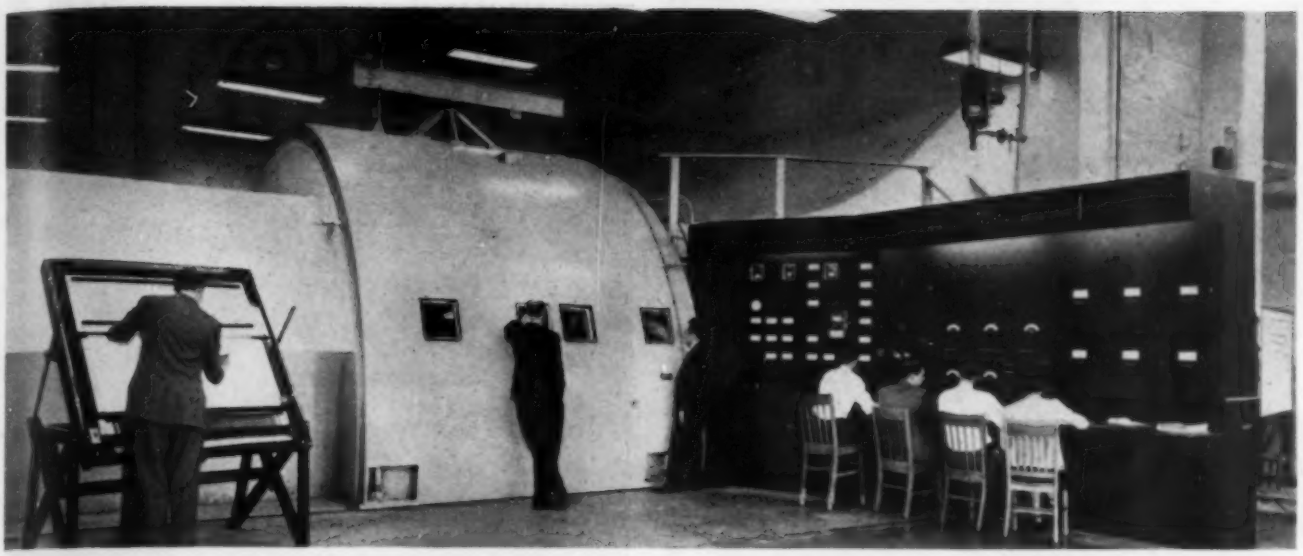
Fig. 4—These curves shows the seasonal variation of sun load calculated for a typical building in Washington, D. C.



[A second article by Mr. McGrath will describe types of air conditioning equipment which may be used in multi-room buildings.]

* * *

At its annual meeting last month the Midwest Stoker Association elected J. J. Hayes, of the Auburn Stoker Co., president, and named W. J. O'Neil, Iron Fireman Mfg. Co., vice-president, and J. G. Beard, Illinois Iron & Bolt Co., secretary-treasurer.

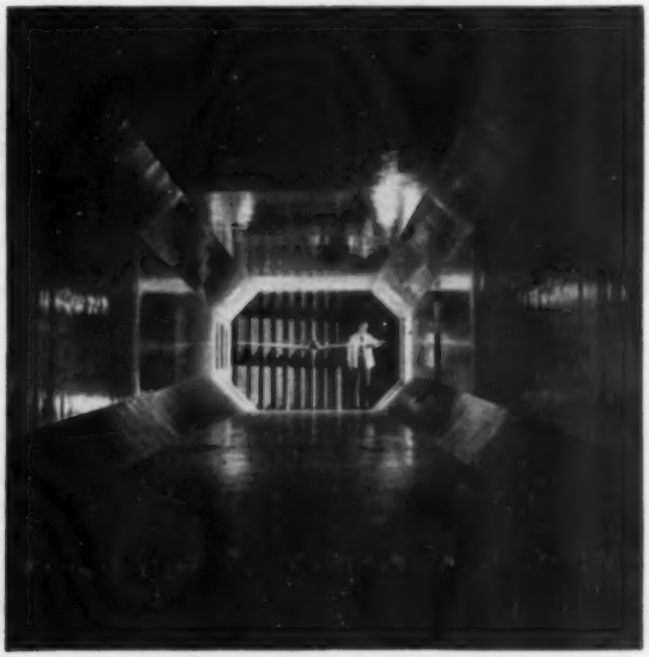


Top—Control and observation facilities for the large wind tunnel recently completed by the Austin Co., engineers and builders, for Boeing Aircraft Co., Seattle, are concentrated in this area, alongside the welded steel pressure cap which encloses the critical test section. Controls and automatic recording instruments are included in the large instrument panel on the right. The pressure cap, seen in the center, is mounted on rollers and equipped with pushbutton controls which move it back and forth to give access to the test area. Models and full scale test sections up to 11 ft in width are lowered into test position from the monorail which extends from the model building area to this location directly above the test section. The easel on the left contains a 100 tube manometer used to register forces on models

★ ★ ★ WIND TUNNEL ★ ★ ★

Left—This view of turning vanes installed at each of the four corners of the 450 ft rectangular bore in the Boeing wind tunnel illustrates the construction of these units which guide the air flow in a manner which eliminates turbulence and produces maximum wind velocity. Cold water removes the heat generated during high speed operation of the tunnel. The water is fed by a centrally located pipe in each vertical series of vanes, and holes are drilled in these pipes to spray the water against the walls of the vane. The vanes were installed in an adjustable fashion, but will be welded into permanent position after the completion of tests to determine just what angles will produce the most successful results. The engineer seen in the background is examining the sections which have been coated with greases of different types to determine their efficiency as dust collectors

Right—Tolerances of ⅛ in. were maintained throughout reinforced concrete extending for more than 150 ft from the bellmouth in the background through this diffuser section in the Boeing wind tunnel. The air flows through the turning vane in the extreme background into the bellmouth, where it reaches peak velocity in the tunnel's test section



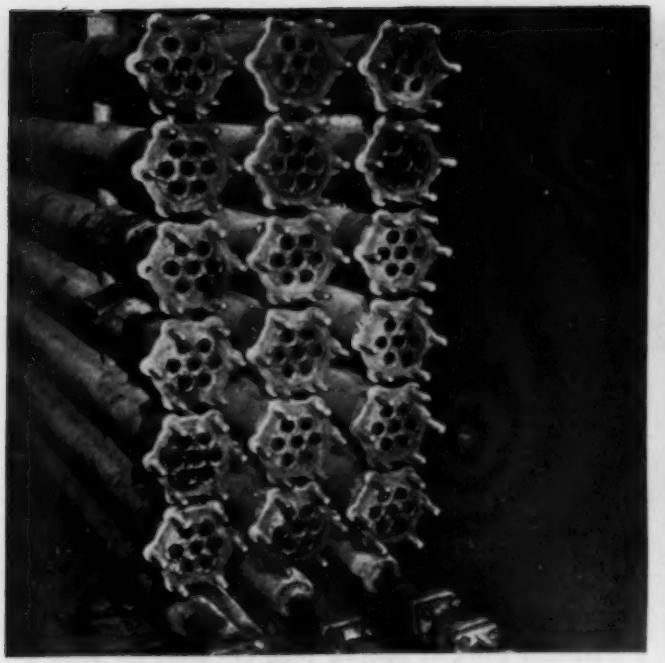


Fig. 1—Replacement of the water tubes in the condenser unit required 252 individual welds

Fig. 2—A first class welding job was necessary since the working pressure of the unit is 1200 psi

Air Conditioning Condenser Unit Is Repaired by Oxyacetylene Welding

Replacement of Water Tubes Keeps Theater Cooling System Operating

THE AIR CONDITIONING system in a large motion picture theater, one of a nationwide chain, was put out of commission because the water tubes in the carbon dioxide condenser unit corroded away. By means of the oxyacetylene welding and cutting process, however, the old tubes were replaced with new ones and the system is now good for many seasons to come.

The condenser consists of 18 lengths of 6 in. steel pipe, through each of which pass seven 1¼ in. steel water tubes. These tubes are welded at each end into steel headers 1½ in. thick, making a total of 252 welds. The old tubes were of standard weight pipe but they were replaced with extra heavy pipe, with an anticipated longer life because of the greater wall thickness.

Since new headers were not available, it was necessary to save and re-use the old ones. Considerable care had to be exercised, therefore, in removing the old tubes so as not to ruin the headers. The old welds and the ends of the old tubes were cut out with a cutting blowpipe. By careful manipulation, the operator was able to remove the tubes without damaging the headers and at the same time bevel each hole, thus preparing it for welding in the replacement tube. The unit operates at 1200 psi working pressure and all welds, therefore, had to be perfectly executed.

Although all of the 252 welds had to withstand this high working pressure, it was not possible to reinforce them very much because the builtup metal would prevent the return bend castings from being drawn up tightly on the studs and would also interfere with the free circulation of the cooling water. The appearance of the welds shows clearly in Fig. 2.

This is the second theater in this chain in which the cooling system has been restored to service by oxyacetylene welding. Others are scheduled to be rebuilt.

[Photos and information courtesy of Oxy-Acetylene Tips and The Linde Air Products Co.]

ASTM SPEAKERS STRESS ADVISABILITY OF TAKING "MYSTERY" FROM WATER TREATMENT

● *At the annual meeting of the American Society for Testing Materials, Dr. W. C. Schroeder stressed the necessity of removing insofar as possible the mystery surrounding water treatment and then outlined the basis for determining and recording water characteristics in common terms—which in essence involves a comparison of the water in question and its chemical makeup with nine standard samples that have been developed by an ASTM committee. These nine samples are detailed in a paper by W. D. Collins and comprise typical waters encountered in the operation of industrial establishments. Complete analysis of these have been made and with their use is offered a tool for expressing the meaning of water analysis in understandable language.*

Heating and Air Conditioning Systems and Insulation Convert Warehouse for

PENICILLIN PRODUCTION

By J. C. Siegesmund, Assistant Director, Engineering Division, Eli Lilly and Co.

PENICILLIN, THE drug that almost overnight became an essential wartime product, has developed into an extensive production program. A number of manufacturers are now producing the "miracle drug," each using one of several of the recognized methods: the surface type of mold grown in two-quart bottles, the deep culture method carried out in tanks of several thousand gallon capacity, or the surface pan or bran method. To date, no published statement of the successful synthesis of the drug has been made.

When Eli Lilly and Co. joined in this wartime program, the management—recognizing the urgency for this drug—felt that no time should be lost in expediting its production. A four story brick building of mill type construction, used for warehouse purposes, was converted. The building consists of three floors and a basement having dimensions of 86 ft x 148 ft x 12 ft floor heights. The entire top floor was set aside for incubator purposes; the second floor was set aside for harvesting the material from the bottles, washing the bottles, filling them with media, autoclaving, and planting them with the proper mold culture; and the first floor was given over to extraction, purification, drying, filling, and finishing ready for shipment. Approximately half of the basement is used for the refrigeration and heat exchange equipment.

The refrigerating and controlled air temperature equipment serves five different units in the various steps of the process; these units are the incubator and planting cages, the chill room, the jacketed processing tanks, the freezer room, and the filling and finishing department. The outside air supply requirements of 6000 cfm for the incubator, planting rooms, and chill room are served by a common unit. The air is filtered by mechanical and electrical filters; 2000 cfm is directed to the incubator, 2000 to the planting cages, and 2000 to the chill room. Conventional air operated temperature controls, dampers, cooling and heating coils are used with this equipment.

Temperature Limits

It was discovered early in the growing of the penicillin mold that there were temperature limits at which the mold grew best and produced the maximum harvest. If the temperature of the culture media went above 73 F, there would be a decrease in the penicillin produced and if the temperature went below 70 F, a longer period of time would be required for the mold growth with some reduction in yield. The mold feeds on the mineral salts and carbohydrates in the culture media; the reaction generates heat that must be removed by some means of cooling. Since the mold grows best in the temperature range of 70 to 73 F, some means of controlling the incubator temperature as well as removing the generated heat in the bottles is necessary. This is where air temperature control comes into the picture. In some installations, the control of humidity in the incubator has been deemed necessary, but in this plant, using liquid media culture, no consideration was given to humidity control, emphasis being placed on controlled air temperature.

Since the outside air temperatures vary below and above the desired temperatures of 70 to 73 F both in winter and in summer, it was of course necessary to provide means for heating the incubator space in the winter and for cooling this space in the summer. To maintain reasonably uniform temperatures, say 1 F plus or minus from the floor to the ceiling in the incubator room, the ceiling height was limited to 8½ ft. It was deemed advisable to build the drop ceiling of plywood construction insulated above with 4 in. of mineral wool. The space above the drop ceiling varies from 2½ ft to 4½ ft in height. In the corners of the side walls of the attic space, there were installed air inlet louvers with sliding shutters, and on the roof there were installed several revolving roof ventilators with tight dampers.

To meet winter conditions, heating coils with temperature controlled steam valves were installed in the attic space and the dampers in the roof ventilators are closed, as are the air inlets in the attic side walls. For summer operation, the steam coils are shut off, and the dampers in the roof ventilators and the side wall air inlet grilles are opened. The windows in the incubator area were sealed with gypsum board insulated with mineral wool and finished on the inside with plywood. The brick walls were faced with 2 in. x 4 in. wooden studs on 2 ft centers, insulated with mineral wool batts and finished on the inside with plywood. To eliminate infiltration through the wooden floor, it was covered with asphalt block 1 in. thick laid in mastic. This also gives a very good trucking surface.

The two-quart bottles to be incubated in this space are stacked in metal racks with expanded metal shelves, each rack holding 200 bottles. The construction is such as to permit maximum circulation of air around the bottles. Space for approximately 500 racks is available

in the incubator room. The racks are moved to and from location with hydraulic lift trucks.

Zone Control Used

In designing the air temperature control apparatus, it was realized that zone control would be the most satisfactory since a day's run of bottles would be placed in one or two zones. In some stages of the incubation period, considerable heat is given off by the mold growth; this heat has to be removed to avoid raising the temperature within the culture media above the desired growing temperature.

The incubator space is divided into nine zones, each being supplied with a ceiling hung air diffuser unit that will meet both summer and winter conditions. A 1¼ in. water line supplies tempered water to the coils in the diffuser. In each zone is an air operated dual type temperature control, for summer and winter conditions, in conjunction with an air actuated modulating valve in the water line to the diffuser coils. To the air inlet of each diffuser is connected an outside air supply duct of 200 cfm, and two properly placed recirculating ducts of 1900 cfm each. The discharge of the diffuser is extended about 10 ft with a horizontal vane type distribution grille.

In the duct for the outside air supply, there are two air operated thermostats. One thermostat is set at 35 F, as this temperature was found by experience to be the dividing zone between winter and summer operation. It changes the dual zone thermostats in the incubator and the three-way valve on the air system for the control instruments and valves from a summer air pressure of 17 psi to a winter pressure of 13 psi. The other thermostat, set at 40 F, operates the master temperature controller in the circulating water line to the diffusers in the incubator and the heating and cooling coils in the air units serving the planting rooms and incubator. The master temperature controller in the water line brings the three compressors into operation as the load demands may require through a differential air pressure setting. This master controller also operates a modulating valve in the steam line to the heat exchanger, heating the circulating water for winter conditions when the requirements call for heating of the incubator space.

To speed production of penicillin—essential wartime product—Eli Lilly and Co. converted a four story brick building of mill type construction, formerly used for warehouse purposes, by installation of heating and air conditioning equipment, insulation of walls and ceilings, and closing up of windows in some spaces by means of gypsum board with mineral wool insulation, finished on the inside with plywood . . . Production of this "miracle drug" depends upon temperature control winter and summer, careful air cleaning, ventilation, and in some steps dehumidification.

The refrigeration designed for the incubator space resolved itself into three 25 ton "Freon" compressors with two condensers each of 60 ton capacity designed for cooling water having a temperature of 80 F. This arrangement allows for the cleaning of one condenser, as the other will carry the load for a short period of time during the cleaning period. This refrigeration is expanded into a shell and tube water cooler of sufficient capacity to absorb a 75 hp refrigerating load. Two 200 gpm pumps, each being of sufficient capacity to carry the load, circulate the water to the diffusing units in the incubator. For winter operation, a shell and tube water heater of 300,000 Btu capacity with steam at 7 psi pressure heats some of the water bypassed through it when the thermostat in the outside air supply calls for winter operating conditions. The three compressors operate on differential pressure controlled thermostats that bring the compressors into service depending on the refrigeration load required.

The chill room is the room in which the extraction and purification of the drug is done. It is provided with a coil and fan unit with direct "Freon" expansion to the coils. To partially meet the load for the operations carried on in this room, a 15 hp compressor with the conventional controls is required. The load requirements of the chill room made it necessary to install also some direct expansion coils along two walls; these coils are supplied with refrigeration from a 10 hp compressor unit. Because of the semi-open handling of amyl acetate, 2000 cfm of outside air is supplied to this room and the same amount is exhausted to the outside.

In the processing of penicillin, some steps call for jacketed tanks with agitators to chill the liquid as rapidly as possible. A 35 per cent alcohol-water circulating medium at 42 F is pumped through the jackets of the tanks by a pump having a capacity of 60 gpm. A 25 hp compressor unit with a cooler and conventional controls satisfactorily meets the requirements.

At some stages in the process, it is necessary to have a small freezer room with a holding temperature of 4 F. This room has banks of direct expansion coils served by a 3 hp "Freon" compressor.

Dry Air for Filling

The finished product is a dry powder which absorbs moisture readily and must be filled under dry conditions. The filling and finishing department is supplied with dry, cool air from a 5 hp unit cooler.

With so little knowledge available on the manufacture of penicillin on a rather large scale, it sometimes seems amazing that many mistakes were not made. As a whole, the design of the equipment in this plant has been quite satisfactory. Much progress is being made in the development of this drug, and the near future may see many changes in production processes as a result of research—which means progress and benefit to all humanity.

on Corrosion of Heating Plants

From Scotty-Grams, a bulletin issued to operating personnel of the Chicago Board of Education by John Howatt, chief engineer, and member of HPAC's board of consulting and contributing editors

PROPER MAINTENANCE of equipment during periods of light load or complete shutdown for extended periods should be considered important by every operating engineer. Periods of shutdown of heating plants occur in the summer when the attention of the engineer is generally required in the performance of duties other than operating the equipment. A delay in taking the proper safeguards during the first few days a plant is idle may result in irreparable damage by corrosion. In most plants the mechanical equipment is situated in basements; dampness is often a condition to combat in these spaces. Even those most devoid of knowledge of mechanics and chemistry know that in damp places iron in its various forms if exposed will quickly acquire a coating of rust. Common as is this knowledge, the underlying scientific facts of why this is true are not yet known.

Causes of Corrosion

Maintenance of anything is for the purpose of preserving it in its state of usefulness for as long a period as possible. Many things man uses are artificial in that they are taken from their natural state, processed, and made fit for service. This is true of one of our most widely used metals—iron, in all its forms. In its natural state iron ore is found in the form of hematite or ferric oxide (Fe_2O_3). Iron is found in other forms also but the great bulk of its natural state is in the form of oxides of iron. Manufactured iron or steel has a strong tendency to return to its natural form; this is quite evident to anyone who will observe the gradual transition of new steel to iron oxide.

Much that is known about corrosion has been learned from observation, and while many of the theories are controversial, there are a few indisputable facts. (1) Necessary presence of moisture. (2) Exact function of moisture is not known except that it does aid electrolytic action. (3) Oxygen must be present to form iron oxide.

Protecting Metal Surfaces

The terms "oxidation," "rust," and "corrosion" are frequently used synonymously. By exact definition there are differences, but not so much we need consider them beyond their common usage. Pitting is one peculiar case of corrosion, and is caused by the setting up of an electrolytic cell in a minute opening in the iron surface from a bit of scale or other foreign substance pressed into the metal or by hair cracks. In pitting, corrosion starts at the bottom of the crack and as time goes on continues to form an increasingly larger pitted area.

Where possible, metal surfaces should be protected from air and moisture by the application of oil, grease, or other substance that will prevent oxygen from reaching the metal. Metallic surfaces such as metal partitions are best protected from corrosion by painting.

Proper care of boilers to prevent corrosion is of vital importance in these times of critical materials. During the operating periods this is done by boiler water analysis and use of proper boiler compounds. External surfaces should be kept free of soot, as soot when moistened by air produces an acid that has a corrosive effect on metal. It is important that breechings too be thoroughly cleaned of all soot. Steps should be taken to ventilate the boiler room as freely as possible in order to keep it dry. External surfaces of boiler heads, tubes, and breechings and smoke boxes of a design where it can be done should be wire brushed down to the metal, completely removing all soot. A preservative or covering should then be applied to these surfaces. A preservative which has given good results is one quart of boiled linseed oil with graphite mixed to the consistency of paint. This mixture is heated to boiling. A small amount of turpentine is then added to give the mixture quick drying properties. Application is made to the metal surfaces with a paint brush and in about 48 hr a hard dry coating will result, giving a good protection to the metal from the corrosive action of air moisture. Any mixture or method which the operating engineer has found practical in slowing down the attacks of corrosion may be used.

The rule of life, "Ashes to ashes and dust to dust," cannot be stopped, but its application can be delayed. Tremendous values in metal products are destroyed every year by corrosion. Values rust away faster than they wear away. Keep the surfaces protected.

GET IN THE FIGHT ON FUEL WASTE!

COMPARATIVE ENGINEERING DATA ON REFRIGERANTS GIVEN IN NEW TABLES

NEW REFRIGERANTS whose field of use is not well defined are appearing today, and others may be expected in the future. Of the several available refrigerants, "Freon-12" and ammonia are the most widely used. "Freon-12" is employed in air conditioning work and is finding many uses in industrial refrigeration also. Ammonia is widely used in ice making plants and in industrial applications. For centrifugal machines, refrigerants like "F-11" and "F-113" are used because of their desirable properties for this type of compressor. Other new refrigerants will probably find their places in definite types of applications in the expected postwar expansion of refrigeration and air conditioning.

In deciding which refrigerant to use under a specific set of conditions, tables are needed which give engineering data such as weight and volume of refrigerant to be circulated per ton, and horsepower and capacity. Such tables, in addition to the basic tables of thermodynamic properties, are of value in

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Engineers need information on weight and volume of a refrigerant to be circulated, and horsepower and capacity, in order to decide whether a refrigerant is suitable for a given set of circumstances. Tables of such data for a number of refrigerants have been prepared. Those for ammonia are presented here, others will appear later.

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showing at a glance just which refrigerant would be desirable under a given set of circumstances. For this reason various sets of tables have been prepared for "Freon-11," -12, -21, -22,* and -113, ammonia, methyl chloride, and water vapor. These tables enable the user to make rapid comparisons of the important basic data needed in deciding whether a refrigerant is suitable for a given set of circumstances. Temperatures are shown in degrees Fahrenheit.

The tables are easy to use. The temperature of the liquid ahead of the expansion valve is equal to the condensing temperature if no subcooling takes place. However, a small amount of subcooling usually takes place in most condensers. It is reasonably safe to figure that the temperature of the liquid ahead of the expansion valve will be about 5 F lower than the actual condensing temperature. The actual condensing temperature corresponding to any given head pressure can, of course, be found in the tables for saturated liquid.

*See HPAC, June 1944, pp. 337-338, and July 1944, p. 409.

Ammonia—Weight of refrigerant to be circulated
(Saturated vapor leaving evaporator)
Lb per min per ton of refrigerating capacity

Evap Temp	Temperature of liquid ahead of expansion valve													
	60	65	70	75	80	85	90	95	100	105	110	115	120	125
-20	0.403	0.408	0.413	0.418	0.423	0.428	0.433	0.439	0.445	0.451	0.457	0.463	0.470	0.476
-18	.403	.407	.412	.417	.422	.427	.433	.438	.444	.450	.456	.462	.469	.476
-16	.402	.407	.412	.416	.422	.427	.432	.438	.443	.449	.455	.462	.468	.475
-14	.402	.406	.411	.416	.421	.426	.431	.437	.443	.448	.454	.461	.467	.474
-12	.401	.406	.410	.415	.420	.426	.431	.436	.442	.448	.454	.460	.466	.473
-10	0.401	0.405	0.410	0.415	0.420	0.425	0.430	0.436	0.441	0.447	0.453	0.459	0.466	0.472
- 8	.400	.404	.409	.414	.419	.424	.430	.435	.440	.446	.452	.458	.465	.472
- 6	.400	.404	.409	.414	.419	.424	.429	.434	.440	.446	.452	.458	.464	.471
- 4	.399	.404	.408	.413	.418	.423	.428	.434	.439	.445	.451	.457	.464	.470
- 2	.398	.403	.408	.412	.417	.423	.428	.433	.439	.444	.450	.456	.463	.470
0	0.398	0.402	0.407	0.412	0.417	0.422	0.427	0.432	0.438	0.444	0.450	0.456	0.462	0.469
2	.398	.402	.407	.411	.416	.421	.426	.432	.437	.443	.449	.455	.462	.468
4	.397	.401	.406	.411	.416	.421	.426	.431	.437	.443	.448	.454	.461	.467
6	.396	.401	.406	.410	.415	.420	.425	.431	.436	.442	.448	.454	.460	.467
8	.396	.400	.405	.410	.415	.420	.425	.430	.436	.441	.447	.453	.460	.466
10	0.396	0.400	0.404	0.409	0.414	0.419	0.424	0.430	0.435	0.441	0.446	0.453	0.459	0.465
12	.395	.399	.404	.409	.414	.419	.424	.429	.434	.440	.446	.452	.458	.465
14	.395	.399	.404	.408	.413	.418	.423	.428	.434	.440	.445	.451	.458	.464
16	.394	.399	.403	.408	.413	.418	.423	.428	.434	.439	.445	.451	.457	.464
18	.394	.398	.403	.407	.412	.417	.422	.428	.433	.438	.444	.450	.456	.463
20	0.393	0.398	0.402	0.407	0.412	0.417	0.422	0.427	0.432	0.438	0.444	0.450	0.456	0.462
22	.393	.397	.402	.406	.411	.416	.421	.426	.432	.437	.443	.449	.455	.462
24	.392	.397	.401	.406	.411	.416	.421	.426	.431	.437	.443	.448	.455	.461
26	.392	.396	.401	.406	.410	.415	.420	.426	.431	.436	.442	.448	.454	.460
28	.392	.396	.400	.405	.410	.415	.420	.425	.430	.436	.442	.448	.454	.460
30	0.391	0.396	0.400	0.405	0.409	0.414	0.419	0.424	0.430	0.435	0.441	0.447	0.453	0.459
32	.391	.395	.400	.404	.409	.414	.419	.424	.429	.435	.440	.446	.452	.459
34	.390	.395	.399	.404	.409	.414	.418	.424	.429	.434	.440	.446	.452	.458
36	.390	.394	.399	.403	.408	.413	.418	.423	.428	.434	.440	.445	.452	.458
38	.390	.394	.398	.403	.408	.413	.418	.423	.428	.434	.439	.445	.451	.457
40	0.389	0.394	0.398	0.403	0.407	0.412	0.417	0.422	0.428	0.433	0.439	0.444	0.450	0.457
42	.389	.393	.398	.402	.407	.412	.417	.422	.427	.433	.438	.444	.450	.456
44	.389	.393	.397	.402	.407	.411	.416	.422	.427	.432	.438	.444	.450	.456
46	.388	.392	.397	.401	.406	.411	.416	.421	.426	.432	.437	.443	.449	.455
48	.388	.392	.397	.401	.406	.411	.416	.421	.426	.431	.437	.443	.449	.455
50	0.388	0.392	0.396	0.401	0.406	0.410	0.415	0.420	0.426	0.431	0.436	0.442	0.448	0.454
52	.387	.392	.396	.400	.405	.410	.415	.420	.425	.430	.436	.442	.448	.454
54	.387	.391	.396	.400	.405	.410	.414	.420	.425	.430	.436	.441	.447	.454
56	.387	.391	.395	.400	.404	.409	.414	.419	.424	.430	.435	.441	.447	.453
58	.386	.390	.395	.399	.404	.409	.414	.419	.424	.429	.435	.441	.446	.453

Ammonia—Volume of refrigerant to be compressed

(Saturated vapor leaving evaporator)

Cu ft per min per ton of refrigerating capacity

Evap Temp	Temperature of liquid ahead of expansion valve													
	60	65	70	75	80	85	90	95	100	105	110	115	120	125
-20	5.92	5.99	6.06	6.13	6.21	6.29	6.36	6.45	6.53	6.62	6.70	6.80	6.89	6.99
-18	5.63	5.69	5.76	5.83	5.90	5.97	6.05	6.12	6.20	6.28	6.37	6.46	6.55	6.64
-16	5.35	5.41	5.47	5.54	5.60	5.67	5.74	5.82	5.89	5.97	6.05	6.13	6.22	6.31
-14	5.09	5.14	5.20	5.27	5.33	5.40	5.46	5.53	5.60	5.68	5.75	5.83	5.92	6.00
-12	4.84	4.89	4.95	5.01	5.07	5.13	5.20	5.26	5.33	5.40	5.47	5.55	5.63	5.71
-10	4.61	4.66	4.71	4.77	4.83	4.89	4.95	5.01	5.07	5.14	5.21	5.28	5.36	5.43
- 8	4.39	4.44	4.49	4.54	4.60	4.66	4.71	4.77	4.83	4.90	4.96	5.03	5.10	5.17
- 6	4.18	4.23	4.28	4.33	4.38	4.44	4.49	4.55	4.61	4.67	4.73	4.79	4.86	4.93
- 4	3.99	4.03	4.08	4.13	4.18	4.23	4.28	4.33	4.39	4.45	4.51	4.57	4.63	4.70
- 2	3.80	3.85	3.89	3.94	3.98	4.03	4.08	4.13	4.19	4.24	4.30	4.36	4.42	4.48
0	3.63	3.67	3.71	3.76	3.80	3.85	3.89	3.94	3.99	4.05	4.10	4.16	4.21	4.27
2	3.46	3.50	3.54	3.59	3.63	3.67	3.72	3.76	3.81	3.86	3.91	3.97	4.02	4.08
4	3.31	3.35	3.38	3.42	3.47	3.51	3.55	3.60	3.64	3.69	3.74	3.79	3.84	3.90
6	3.16	3.20	3.23	3.27	3.31	3.35	3.39	3.43	3.48	3.52	3.57	3.62	3.67	3.72
8	3.02	3.06	3.09	3.13	3.16	3.20	3.24	3.28	3.32	3.37	3.41	3.46	3.51	3.56
10	2.89	2.92	2.95	2.99	3.03	3.06	3.10	3.14	3.18	3.22	3.26	3.31	3.35	3.40
12	2.76	2.79	2.83	2.86	2.89	2.93	2.96	3.00	3.04	3.08	3.12	3.16	3.21	3.25
14	2.65	2.67	2.71	2.74	2.77	2.80	2.84	2.87	2.91	2.95	2.99	3.03	3.07	3.11
16	2.53	2.56	2.59	2.62	2.65	2.68	2.72	2.75	2.79	2.82	2.86	2.90	2.94	2.98
18	2.43	2.45	2.48	2.51	2.54	2.57	2.60	2.63	2.67	2.70	2.74	2.77	2.81	2.85
20	2.32	2.35	2.38	2.40	2.43	2.46	2.49	2.52	2.56	2.59	2.62	2.66	2.69	2.73
22	2.23	2.25	2.28	2.31	2.33	2.36	2.39	2.42	2.45	2.48	2.51	2.55	2.58	2.62
24	2.14	2.16	2.18	2.21	2.24	2.26	2.29	2.32	2.35	2.38	2.41	2.44	2.47	2.51
26	2.05	2.07	2.10	2.12	2.15	2.17	2.20	2.22	2.25	2.28	2.31	2.34	2.37	2.41
28	1.97	1.99	2.01	2.03	2.06	2.08	2.11	2.13	2.16	2.19	2.22	2.25	2.28	2.31
30	1.89	1.91	1.93	1.95	1.98	2.00	2.02	2.05	2.07	2.10	2.13	2.16	2.19	2.22
32	1.81	1.83	1.85	1.87	1.90	1.92	1.94	1.97	1.99	2.02	2.04	2.07	2.10	2.13
34	1.74	1.76	1.78	1.80	1.82	1.84	1.87	1.89	1.91	1.94	1.96	1.99	2.02	2.04
36	1.67	1.69	1.71	1.73	1.75	1.77	1.79	1.82	1.84	1.86	1.89	1.91	1.94	1.96
38	1.61	1.63	1.64	1.66	1.68	1.70	1.72	1.74	1.77	1.79	1.81	1.84	1.86	1.89
40	1.55	1.56	1.58	1.60	1.62	1.64	1.66	1.68	1.70	1.72	1.74	1.77	1.79	1.81
42	1.49	1.50	1.52	1.54	1.56	1.58	1.59	1.61	1.63	1.65	1.68	1.70	1.72	1.74
44	1.43	1.45	1.46	1.48	1.50	1.52	1.53	1.55	1.57	1.59	1.61	1.63	1.66	1.68
46	1.38	1.39	1.41	1.42	1.44	1.46	1.48	1.49	1.51	1.53	1.55	1.57	1.59	1.62
48	1.33	1.34	1.36	1.37	1.39	1.40	1.42	1.44	1.46	1.47	1.49	1.51	1.53	1.56
50	1.28	1.29	1.31	1.32	1.34	1.35	1.37	1.38	1.40	1.42	1.44	1.46	1.48	1.50
52	1.23	1.24	1.26	1.27	1.29	1.30	1.32	1.33	1.35	1.37	1.39	1.40	1.42	1.44
54	1.19	1.20	1.21	1.23	1.24	1.26	1.27	1.29	1.30	1.32	1.33	1.35	1.37	1.39
56	1.14	1.16	1.17	1.18	1.20	1.21	1.22	1.24	1.25	1.27	1.29	1.30	1.32	1.34
58	1.10	1.11	1.12	1.14	1.15	1.17	1.18	1.19	1.21	1.22	1.24	1.26	1.27	1.29

Ammonia—Theoretical capacity of refrigerating compressors

(Saturated vapor leaving evaporator)

Tons per cu ft per min of vapor compressed

Evap Temp	Temperature of liquid ahead of expansion valve													
	60	65	70	75	80	85	90	95	100	105	110	115	120	125
-20	0.169	0.167	0.165	0.163	0.161	0.159	0.157	0.155	0.153	0.151	0.149	0.147	0.145	0.143
-18	.178	.176	.174	.172	.169	.168	.165	.163	.161	.159	.157	.155	.153	.151
-16	.187	.185	.183	.181	.179	.176	.174	.172	.170	.168	.165	.163	.161	.158
-14	.196	.195	.192	.190	.188	.185	.183	.181	.179	.176	.174	.172	.169	.167
-12	.207	.204	.202	.200	.197	.195	.192	.190	.188	.185	.183	.180	.178	.175
-10	0.217	0.215	0.212	0.210	0.207	0.204	0.202	0.200	0.197	0.195	0.192	0.189	0.187	0.184
- 8	.228	.225	.223	.220	.217	.215	.212	.210	.207	.204	.202	.199	.196	.193
- 6	.239	.236	.234	.231	.228	.225	.223	.220	.217	.214	.211	.209	.206	.203
- 4	.251	.248	.245	.242	.239	.236	.234	.231	.228	.225	.222	.219	.216	.213
- 2	.263	.260	.257	.254	.251	.248	.245	.242	.239	.236	.233	.229	.226	.223
0	0.275	0.272	0.270	0.266	0.263	0.260	0.257	0.254	0.251	0.247	0.244	0.240	0.238	0.234
2	.289	.286	.282	.279	.275	.272	.269	.266	.262	.259	.256	.252	.249	.245
4	.302	.299	.296	.292	.288	.285	.282	.278	.275	.271	.267	.264	.260	.256
6	.316	.313	.310	.306	.302	.299	.295	.292	.287	.284	.280	.276	.272	.269
8	.331	.327	.324	.319	.316	.313	.309	.305	.301	.297	.293	.289	.285	.281
10	0.346	0.342	0.339	0.334	0.330	0.327	0.323	0.318	0.314	0.311	0.307	0.302	0.299	0.294
12	.362	.358	.353	.350	.346	.341	.338	.333	.329	.325	.321	.316	.312	.308
14	.377	.375	.369	.365	.361	.357	.352	.348	.344	.339	.334	.330	.326	.322
16	.395	.391	.386	.382	.377	.373	.368	.364	.358	.355	.350	.345	.340	.336
18	.412	.408	.403	.398	.394	.389	.385	.380	.375	.370	.365	.361	.356	.351
20	0.431	0.426	0.420	0.417	0.412	0.407	0.402	0.397	0.391	0.386	0.382	0.376	0.372	0.366
22	.448	.444	.439	.433	.429	.424	.418	.413	.408	.403	.398	.392	.388	.382
24	.467	.463	.459	.452	.446	.442	.437	.431	.426	.420	.415	.410	.405	.398
26	.488	.483	.476	.472	.465	.461	.455	.450	.444	.439	.433	.427	.422	.415
28	.508	.503	.498	.493	.485	.481	.474	.469	.463	.457	.450	.444	.439	.433
30	0.529	0.524	0.518	0.513	0.505	0.500	0.495	0.488	0.483	0.476	0.469	0.463	0.457	0.450
32	.552	.546	.541	.535	.526	.521	.515	.508	.503	.495	.490	.483	.476	.469
34	.575	.568	.562	.556	.549	.543	.535	.529	.524	.515	.510	.503	.495	.490
36	.599	.592	.585	.578	.571	.565	.559	.549	.543	.538	.529	.524	.515	.510
38	.621	.613	.610	.602	.595	.588	.581	.571	.565	.559	.552	.543	.538	.529
40	0.645	0.641	0.633	0.625	0.617	0.610	0.602	0.595	0.588	0.581	0.575	0.565	0.559	0.552
42	.671	.667	.658	.649	.641	.633	.629	.621	.613	.606	.595	.588	.581	.575
44	.699	.690	.685	.676	.667	.658	.654	.645	.637	.629	.621	.613	.602	.595
46	.725	.719	.709	.704	.694	.685	.676	.671	.662	.654	.645	.637	.629	.617
48	.752	.746	.735	.730	.719	.714	.704	.694	.685	.680	.671	.662	.654	.641
50	0.781	0.775	0.763	0.758	0.746	0.741	0.730	0.725	0.714	0.704	0.694	0.685	0.676	0.667
52	.813	.806	.794	.787	.775	.769	.758	.752	.741	.730	.719	.714	.704	.694
54	.840	.833	.826	.813	.806	.794	.787	.775	.769	.758	.752	.741	.730	.719
56	.877	.862	.855	.847	.833	.826	.820	.806	.800	.787	.775	.769	.758	.746
58	.909	.901	.893	.877	.870	.855	.847	.840	.826	.820	.806	.794	.787	.775

Ammonia—Theoretical horsepower of refrigerating compressors

(Saturated vapor entering compressor)

Horsepower per ton

Evap Temp	Condensing temperature 60	65	70	75	80	85	90	95	100	105	110	115	120
-20	1.04	1.11	1.19	1.27	1.36	1.44	1.53	1.62	1.71	1.80	1.90	2.00	2.10
-18	0.999	1.08	1.15	1.23	1.32	1.40	1.49	1.57	1.66	1.76	1.85	1.95	2.05
-16	0.965	1.04	1.12	1.20	1.28	1.36	1.44	1.53	1.62	1.71	1.81	1.90	2.00
-14	0.930	1.00	1.08	1.16	1.24	1.32	1.40	1.49	1.58	1.67	1.76	1.85	1.95
-12	0.896	0.969	1.05	1.12	1.20	1.28	1.36	1.45	1.53	1.62	1.71	1.81	1.90
-10	0.864	0.935	1.01	1.09	1.16	1.24	1.32	1.41	1.49	1.58	1.67	1.76	1.86
- 8	.830	.902	0.975	1.05	1.13	1.20	1.28	1.37	1.45	1.54	1.62	1.72	1.81
- 6	.799	.869	0.941	1.02	1.09	1.17	1.25	1.33	1.41	1.49	1.58	1.67	1.76
- 4	.767	.836	0.908	0.980	1.05	1.13	1.21	1.29	1.37	1.45	1.54	1.63	1.72
- 2	.737	.806	0.876	0.948	1.02	1.10	1.17	1.25	1.33	1.41	1.50	1.59	1.68
0	0.706	0.773	0.843	0.913	0.986	1.06	1.14	1.21	1.29	1.37	1.46	1.54	1.63
2	.676	.742	.811	.881	.952	1.03	1.10	1.18	1.25	1.34	1.42	1.50	1.59
4	.648	.713	.782	.850	.920	0.993	1.07	1.14	1.22	1.30	1.38	1.46	1.55
6	.619	.684	.751	.819	.888	0.960	1.03	1.11	1.18	1.26	1.34	1.42	1.51
8	.590	.653	.719	.787	.856	0.925	0.998	1.07	1.15	1.22	1.30	1.38	1.47
10	0.563	0.626	0.691	0.757	0.824	0.894	0.965	1.04	1.11	1.19	1.26	1.35	1.43
12	.536	.597	.661	.726	.793	.861	.931	1.00	1.08	1.15	1.23	1.31	1.39
14	.509	.570	.633	.697	.763	.830	.899	0.970	1.04	1.12	1.19	1.27	1.35
16	.483	.543	.606	.668	.734	.800	.868	0.938	1.01	1.08	1.16	1.23	1.31
18	.457	.516	.577	.640	.706	.770	.836	0.905	0.976	1.05	1.12	1.20	1.28
20	0.430	0.489	0.550	0.612	0.676	0.740	0.806	0.874	0.943	1.02	1.09	1.16	1.24
22	.407	.465	.524	.586	.648	.712	.777	.845	.913	0.983	1.05	1.13	1.20
24	.381	.439	.498	.558	.620	.683	.747	.814	.881	0.951	1.02	1.09	1.17
26	.357	.414	.472	.532	.592	.655	.719	.785	.850	0.919	0.989	1.06	1.14
28	.333	.390	.448	.506	.566	.628	.690	.755	.820	0.888	0.957	1.03	1.10
30	0.309	0.366	0.422	0.480	0.539	0.600	0.662	0.725	0.790	0.857	0.925	0.995	1.07
32	.287	.342	.398	.455	.513	.574	.634	.697	.762	.828	.894	.963	1.03
34	.264	.319	.375	.430	.489	.548	.608	.669	.733	.799	.864	.933	1.00
36	.242	.296	.351	.406	.463	.521	.581	.642	.704	.769	.835	.902	0.970
38	.220	.273	.327	.382	.438	.496	.554	.615	.676	.740	.805	.871	0.939
40	0.197	0.250	0.303	0.358	0.413	0.471	0.529	0.589	0.649	0.712	0.776	0.842	0.908
42	.177	.229	.281	.336	.391	.447	.504	.563	.624	.686	.748	.813	.879
44	.157	.207	.259	.313	.367	.422	.479	.537	.597	.658	.721	.784	.849
46	.136	.185	.237	.290	.344	.398	.454	.511	.571	.631	.692	.755	.820
48	.116	.165	.216	.268	.321	.375	.430	.487	.545	.605	.666	.728	.792
50	0.0960	0.145	0.195	0.246	0.298	0.352	0.407	0.463	0.520	0.579	0.638	0.701	0.764
52	.0758	.125	.174	.224	.276	.329	.383	.438	.495	.553	.612	.673	.736
54	.0566	.104	.154	.203	.255	.307	.361	.415	.471	.528	.586	.647	.709
56	.0374	.0848	.133	.182	.234	.285	.338	.392	.447	.504	.561	.621	.682
58	.0182	.0654	.114	.162	.213	.263	.315	.368	.423	.479	.535	.594	.654

Ammonia—Theoretical horsepower per cu ft of vapor compressed per min

Evap Temp	Condensing temperature 60	65	70	75	80	85	90	95	100	105	110	115	120
-20	0.175	0.186	0.197	0.208	0.219	0.230	0.241	0.251	0.262	0.273	0.284	0.294	0.305
-18	.178	.189	.201	.212	.223	.235	.246	.257	.269	.280	.291	.302	.313
-16	.180	.192	.204	.216	.228	.240	.252	.263	.275	.287	.298	.310	.321
-14	.183	.195	.208	.220	.232	.245	.257	.273	.281	.294	.306	.318	.330
-12	.185	.198	.211	.224	.237	.249	.262	.275	.288	.300	.313	.325	.338
-10	0.187	0.201	0.214	0.228	0.241	0.254	0.268	0.281	0.294	0.307	0.320	0.333	0.346
- 8	.189	.203	.217	.231	.245	.259	.273	.286	.300	.314	.327	.341	.355
- 6	.191	.206	.220	.235	.249	.263	.278	.292	.306	.320	.335	.349	.363
- 4	.192	.208	.223	.237	.252	.267	.283	.297	.312	.327	.342	.356	.371
- 2	.194	.210	.225	.241	.256	.272	.287	.303	.318	.334	.349	.364	.379
0	0.195	0.211	0.227	0.243	0.259	0.276	0.292	0.308	0.324	0.340	0.355	0.371	0.387
2	.195	.212	.229	.246	.263	.279	.296	.313	.329	.346	.362	.379	.395
4	.196	.213	.231	.248	.265	.283	.301	.318	.335	.352	.369	.386	.403
6	.196	.214	.232	.250	.268	.286	.304	.322	.340	.358	.375	.393	.411
8	.195	.214	.233	.252	.271	.289	.308	.326	.345	.363	.382	.400	.418
10	0.195	0.214	0.234	0.253	0.272	0.292	0.311	0.330	0.350	0.369	0.388	0.407	0.426
12	.194	.214	.234	.254	.274	.294	.314	.334	.354	.374	.393	.413	.433
14	.192	.213	.234	.255	.276	.296	.317	.338	.358	.379	.399	.420	.440
16	.191	.212	.234	.255	.277	.298	.320	.341	.362	.383	.405	.426	.447
18	.188	.210	.233	.255	.278	.300	.322	.344	.366	.388	.410	.432	.454
20	0.185	0.208	0.231	0.255	0.278	0.300	0.323	0.346	0.369	0.392	0.415	0.437	0.460
22	.183	.206	.230	.254	.278	.301	.325	.349	.362	.396	.420	.443	.467
24	.178	.203	.228	.253	.277	.302	.326	.351	.375	.400	.424	.448	.472
26	.174	.200	.225	.251	.276	.302	.327	.353	.378	.403	.428	.453	.478
28	.170	.196	.223	.249	.275	.302	.327	.354	.380	.406	.432	.458	.484
30	0.164	0.192	0.219	0.246	0.273	0.300	0.327	0.354	0.381	0.408	0.435	0.462	0.488
32	.158	.187	.215	.243	.271	.299	.326	.354	.382	.410	.438	.465	.493
34	.152	.181	.211	.239	.268	.297	.326	.354	.384	.413	.441	.469	.498
36	.145	.175	.205	.235	.265	.294	.324	.354	.383	.413	.443	.472	.501
38	.137	.168	.199	.230	.260	.291	.322	.353	.383	.414	.444	.474	.505
40	0.128	0.160	0.192	0.224	0.255	0.287	0.319	0.351	0.382	0.414	0.445	0.477	0.508
42	.119	.152	.185	.218	.251	.284	.317	.349	.382	.415	.447	.479	.511
44	.110	.143	.177	.211	.245	.268	.313	.346	.380	.414	.447	.480	.513
46	.0984	.133	.168	.203	.239	.273	.308	.342	.378	.412	.446	.480	.515
48	.0876	.123	.159	.195	.231	.267	.303	.339	.375	.411	.446	.481	.517
50	0.0752	0.112	0.150	0.186	0.223	0.261	0.298	0.334	0.371	0.408	0.444	0.481	0.518
52	.0616	.100	.138	.176	.215	.253	.291	.328	.367	.405	.442	.480	.518
54	.0477	.0870	.127	.166	.206	.245	.284	.323	.362	.401	.439	.479	.517
56	.0327	.0734	.114	.154	.196	.236	.276	.316	.357	.397	.436	.477	.517
58	.0165	.0587	.101	.142	.184	.226	.267	.309	.350	.391	.432	.473	.514

Heating, Piping & Air Conditioning

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

Journal Section

S. H. Downs
Kalamazoo, Mich.
President

Proceedings of the Semi-Annual Meeting

American Society of Heating and Ventilating Engineers June 19-20, 1944 Grand Rapids, Mich.

THE SEMI-ANNUAL Meeting 1944 attracted 352 members, ladies and guests for the four technical sessions held at the Pantlind Hotel, Grand Rapids, Mich.

The complete proceedings of the first session appeared in the July ASHVE Journal Section (p. 425).

Pres. S. H. Downs, Kalamazoo, Mich., called the meeting to order, after which a series of By-Law Amendments were discussed, and three technical papers were presented on Monday morning, June 19.

The Grand Rapids Meeting was distinguished by the unusually heavy attendance at the technical meetings, and the entertainment planned for free hours was original and appealed strongly to the visiting audience.

The proceedings of the remaining sessions of the Meeting will be found on the following pages:

Second Session—Monday, June 19, 2:00 P. M.

First Vice. Pres. C.-E. A. Winslow, New Haven, presiding officer of the session, announced that the session would be devoted to a discussion of the subject of fuel conservation. He referred to the Society's contribution toward the war effort through its promotion of the fuel conservation program during the past year and also through the 10 per cent of its membership now in military service.

Fuel Conservation

K. C. Richmond, Chicago, editor of *Coal Heat*, introduced the subject by giving a prepared talk on *Education—The Engineer's Major Job in Heating and Fuel Conservation.*

Education, the Engineer's Major Job in Heating and Fuel Conservation

By K. C. Richmond,* Chicago, Ill.

This war service memorandum covers ways and means of furthering better heating and fuel conservation—the present status, maintenance, operation of heating facilities—points out specifically where the responsibility rests for fuel waste—emphasizes the need for wide-spread educational efforts both within the profession and industry as well as among fuel users.

The Basic Needs

If the problems of fuel conservation are to be solved, steps must be taken to:

1. Familiarize all concerned with the importance, needs, possibilities, advantages and opportunities in saving heat, steam or power.

*Editor, Coal-Heat, Member of ASHVE.

2. Sell more fuel and heating dealers on the value of getting in touch with every customer so as to help insure the best results from the fuel or equipment used.

3. Encourage cleaning and inspection of every possible fuel using plant.

4. Provide adequate instructions on better maintenance and operation. Give fuel users a "Heating Service Report" to show specifically what they can do.

5. Reduce all possible heat, steam, power and fuel losses.

6. Assist users of non-familiar fuels.

7. Increase publicity, training and educational efforts.

8. Encourage the use of insulation and other means of fuel savings that do not require the use of critical war materials.

9. Discourage overheating for reasons of health protection or the prevention of colds and absenteeism.

10. Set up standards of performance, comparison, costs, quantities, and results to show what can be—is being done.

When a check is made of the character, condition and method of operation of the majority of heating systems, it is found that only a comparatively small percentage of fuel users have any real conception of the many factors that affect their heating comfort, what happens to the heat they buy, or what is involved in the proper operation and maintenance of the heating systems in their homes, buildings or plants. One reason for this is that half of the heating equipment is in the basement or boiler room, out of sight, and people have been inclined to spend money where it would show.

If heating plants stood at the curb where the neighbors could see them—maybe they would get some of the same sort of attention they now give their automobiles.

That the present status of heating facilities leaves much to be desired, is clearly indicated by a recent survey among smoke inspectors, equipment manufacturers, fuel engineers, and servicemen. Because of their wide experience, observation and close contact with so many fuel users, both large and small, the speaker asked a number of these men the following questions:

(1) What seems to be the present status of the heating facilities in the vast majority of buildings—exclusive of central stations, and the large power plants where skilled management and operating personnel more or less automatically see to it that proper maintenance and operation is secured?
(2) What percentage of these plants are clean?
(3) How about the skill of the average janitor or fireman in the "in between" sized plant?
(4) What percentage of such heating facilities would be logical prospects for modernization or replacement as we go out of the war period?

What the Situation Is—

Here is a summary they wrote:

(1) That less than 20 per cent of the heating plants are in "good condition"—20 to 30 per cent in "fair condition"—60 per cent or more generally are in "poor condition"—depending on the community.

(2) In answer to the questions on "housekeeping" or the way most heating systems are operated, these men declared that less than 10 per cent of the heating plants including those in apartment houses and janitor operated buildings in general, are clean, and are skillfully operated. About 20 per cent are "fairly well" operated.

(3) Unfortunately, time does not permit the use of a number of most interesting direct quotations commenting in detail on the faulty operation and maintenance of the majority of heating systems.

(4) According to these authorities, 50, 60, 75, 80—even 90 per cent of these plants could be modernized or replaced to advantage as we go out of the war period. Certainly, a substantial percentage is now in need of major alterations or repairs—overhauling, modernization or replacement.

What Boiler Manufacturers Say—

In double-checking on the condition, maintenance and operation of heating facilities, several boiler manufacturers were asked what their impressions were at present. Here are some samples:

"The best answer is that 50 to 60 per cent of our tonnage of boiler business normally represents replacements," a past president of ASHVE wrote me. "Not one per cent of the domestic fuel users know how to take proper care of their heating facilities," he commented. "A campaign by the heating industry for the care, repair and modernization of heating equipment would be well worth while."

Another wrote that "right now it would be advantageous to replace about 47 per cent of the nation's domestic heating equipment if materials were available—that 70 per cent need repairs, alterations or modernization."

"There are very few people that know how to take care of their heating facilities. Probably 10 per cent would be a high figure. They unknowingly put up with a certain amount of discomfort rather than try to correct the conditions responsible," explained a third manufacturer.

"The greatest waste of fuel results from just downright carelessness on the part of many homeowners in operating their plants," declared another leading manufacturer.

"The largest possibilities of fuel saving with existing radiator heating plants can be accomplished by putting consumers on notice to condition and to operate their plants properly."

Study of the individual inspection records of several hundred larger buildings shows that "over 87 per cent of the plants surveyed have not been maintained in good operating condition. Survey engineers found burned boiler fronts, doors off the hinges, or missing entirely, breechings in bad shape, as well as grates or tuyeres burned, in addition to passages full of soot and other evidences of neglect."

The Situation in Canada

N. W. Kingsland, Director of Coal Conservation, Department of Munitions and Supply, Ottawa, Canada, after asking the opinions of members of the National Coal Conservation Committee, wrote as follows:

"No two people will have the same idea as to standards in judging the condition of a boiler room. Generally speaking, boiler rooms are in much better condition today than they were 10 or 20 years ago; in other words, the public is becoming more and more conscious of the fact that the heating plant is a vital part of any building. This, of course, does not mean that conditions are yet what they should be, but it does show that progress is being made.

"It seems to be the general opinion that not over 25 per cent of boiler plants can be considered satisfactory from the standpoint of housekeeping.

"It is believed that in 85 per cent of the plants in question, janitors or firemen are not what they should be as far as skill is concerned.

"At least 80 per cent of boiler rooms, burning 75 to 1000 tons of coal per year, should be logical prospects for modernization or replacement in the immediate postwar period. This, of course, does not mean that all equipment is unsatisfactory, but that some changes can be well justified," Mr. Kingsland adds.

Such are the conclusions of a number of the leading heating authorities, engineers and service men. To ignore their estimate of the situation is to play the ostrich.

Fires and Boiler Explosions

As a result of such a situation, it is not surprising that this country suffers from over 200,000 fires annually, directly attributable to faulty heating equipment and chimneys, causing a loss of around 50 million dollars. In Canada, the fire loss directly attributable to furnaces, boilers, stoves, defective chimneys and flues amounted to 6 million dollars last year.

It is estimated that every third day there is a violent boiler explosion in the United States and that the property damage resulting from such occurrences runs each year into the millions of dollars. While the toll of lives taken seldom exceeds 100 in a single year, painful injuries not resulting in death are frequent.

In addition to these, there are much more frequent occurrences in power boilers coming under the heading of tube ruptures. The number of these cannot even be estimated, nor can the damage, but it is safe to say that while the property damage in any single instance may not be extensive, the effect of the rupture is such that interruption to power or heating services is costly.

Another frequent occurrence is the cracking of sections of cast iron heating boilers, usually the result of improper operating methods. As with tube ruptures in power boilers, there is no feasible way of learning the number of such occurrences each year, or of determining the repair bills, but were such figures available, they would be astounding, the evidence appears. The inconvenience of being without

heat at a time when it is greatly needed, is likewise a factor of importance.

The efforts of boiler insurance companies, manufacturers, engineering societies, states and municipal groups, and others in seeing that boilers are properly designed, manufactured, installed and operated, have done much in cutting down the frequency of boiler explosions, but only constant attention to the subject will make possible the continuance of this improved experience.

Overheating and the Health Aspects

Health and absenteeism are concomitant aspects of faulty heating also. Faulty or inadequate control results in overheating which "unnecessarily accentuates the shock to the human body of meeting the outside cold air—and influences susceptibility to respiratory disorders" as the Committee on the Hygiene of Housing of the American Public Health Association has pointed out. (See its report, "Housing for Health.")

The incidence of the common cold is of no mean significance. It is said that 59 million working days are lost due to common colds, plus flu following them—that colds in war industries account for one-half of the lost time—that two adults out of every three suffer from colds during the winter—that in a single week colds may affect one member of one family in three.

Just how many of the colds that 50 million adults suffer from annually, can be charged to overheating, stratification, wide temperature variation—no one knows, yet these are definite factors—so some of the costs of ill health and absenteeism can be charged to the lack of proper temperature control or to overheating. One large Chicago industrial concern has reported reducing absenteeism by 70 per cent by the installation of outside type thermostatic controls.

Prevalence of Overheating

That overheating is all too common, is shown by the large number of office building, hotel and apartment house windows that are left open during the fall, or spring—or on milder days during the winter. Obviously, opening windows is a poor way to control room temperature.

Field tests with calibrated temperature recorders by the Technical Advisory Board of the Anthracite Industry show that the average loss in typical houses without automatic temperature controls resulting from temperatures above 70 deg is 11.7 per cent. In one third of the cases, seasonal loss was from 18 to about 32 per cent.

In these houses, temperatures in the living quarters varied from low to high as follows: 58 to 71—50 to 81—58 to 77—59 to 71— 66 to 85—67 to 76 F.

From a study of a group of leading office buildings by the *Building Managers' Association* of Chicago, "it was determined that the buildings which were checking their heating performance daily on a degree day basis were using 22 per cent less steam than buildings which were making no check at all. Steam consumption of buildings making monthly degree check was 5.8 per cent less than those making no check at all," *Skyscraper Management* has reported. (Jan. 1941.)

With so much overheating and fuel waste among office buildings, isn't it obvious that conditions are far worse among apartment houses where supervision and skilled operation leave much more to be desired? Apartment house temperatures of 80-85 deg are common. Yet, each degree the temperature rises above 70 increases heating costs 3 per cent.

Thus, more adequate temperature regulation is essential to health, to economical operation, and to heating conservation.

Distribution of Heat

Not nearly enough attention has been, or is, paid to the distribution of heat—or what happens to it after it leaves the boiler—which explains much of the faulty heating and fuel loss.

Many buildings should be zoned—must be—if they are to be heated properly and economically. Zoning may be essential, owing to the shape or exposure of a building or if part of it is used for office or housing purposes, and part for stores or manufacturing. Parts of many buildings are being very much overheated in an effort to get heat to colder sections.

The size and pitch of radiators, the type and condition of the vents, valves, traps, piping, affect the distribution of heat materially—and present many opportunities for improvement.

"Outside" type thermostatic controls designed to keep the heating system "in step with the weather" have proven savings in average installations in excess of 15 per cent. (Bul. No. 20 of F.H.A. "When automatic heat control is omitted, fuel consumption estimate for heating should be increased 15 per cent.")

In the improvement of heat distribution rests one of the greatest responsibilities and opportunities in the hands of the heating industry.

What Can Be Done

For the purpose of determining the extent to which one can make economies in the use of steam for heating buildings and of determining which of the many methods of accomplishing these economies gives the best results, a joint study was undertaken by the *National Association of Building Owners and Managers* and the *National District Heating Association*. (See Heating, Piping & Air Conditioning, pages 609-612, October, 1939.) Data on 153 buildings show a 24.8 per cent saving through such efforts; 29.8 per cent in Chicago; 14.4 per cent in St. Louis; 24 per cent in New York; 30.6 per cent in Philadelphia; 28.7 per cent in Baltimore; 25.7 per cent in Indianapolis.

Draft Controls

With all the changes in the direction and velocity of the wind, barometric pressure, humidity, and the temperature differences between the outside and inside of a chimney, it isn't particularly surprising that far too much heat is being wasted in many buildings, owing to the lack of draft control.

Such fluctuations in chimney draft affect the temperature in the combustion chamber, the existing gas temperature, the volume and weight of the gases produced, the time gases remain in contact with heating surface of the boiler, and the velocity of the gases passing through it—thus having a marked influence on the rate of coal consumption and the combustion efficiency.

Excess air and lack of proper draft regulation cost this country more than 10 per cent of the fuel used in 90 per cent of the plants, so the possibilities of fuel saving here are limited only by the sales initiative of the heating industry.

Stokers

What a self-starter and carburetor are to an automobile, that is what a stoker and its controls are to a boiler—a means of feeding air and coal into the firebox and burning it under automatic control, efficiently and without waste.

Due to their design, stokers are gas producers essentially and burn the volatile contents of coal that would be wasted ordinarily, when fired by hand with none too skilled janitors for firemen. Thus, the installation of more stokers can help cut fuel consumption materially.

Records covering several thousand installations in apartment houses show an average reduction in heating costs of 20 to 30 per cent—the amount depending on the load, the climate, fuel costs, etc. Similar savings are being shown in schools, various institutions, or buildings, where heating costs are quite an item.

Where the Responsibility Rests

Obviously, the responsibility for the general faulty operation and lack of proper maintenance of so many heating facilities—and the needless waste of heat and fuel rests squarely on the shoulders of: (1) building owners and operators themselves; (2) fuel producers, equipment manufacturers and their distributive connections; (3) on architects, builders and contractors; (4) on labor, trade and other associations; (5) on governmental authorities.

But the facts are that most fuel users have not come to appreciate the personal importance of proper operation and maintenance of their heating facilities. Yet, the individual who signs the checks just can't evade the responsibility for overall heating costs or waste. Too often he has

pinched pennies—and wasted dollars. All too often, also, he hasn't given the practical, varied problems of heating a tenth of the attention he gives his automobile.

The extent to which many fuel producers and equipment manufacturers have really concerned themselves with what happened to their fuel, boilers, burners or appliances after they got into the customers' basements or boiler rooms, leaves considerable to be desired—from a long range merchandising or engineering viewpoint. The notion that one's job ends when one's boiler goes into the jobber's hands, or the dealer's hands, or into the customer's basement (as the case may be) shows little conceptual integration of the dynamics of customer relationships.

Basically, John Q. Public wants heat, hot water, comfort, steam or power—boilers or equipment and fuels are but a means to an end.

Essentially, therefore, the profession and industry are selling "heat, hot water, comfort, health protection"—not so much cast iron radiation, gallons of oil, cars of coal, or units of this or that.

The XY Fundamentals

What must be remembered is: (1) that the customer judges what he buys by what he gets out of it; (2) that what he gets depends on how he uses it; (3) that neither our fuel or equipment is any better than the skill of the operator; (4) that these are no better than the means of heat distribution—or what happens to the heat after it leaves the boiler.

Hence, if the fuel and heating industries are to help insure the more satisfactory use and sale of their products, considerably more attention will have to be given to educational efforts—both within the trade and among fuel users. Many executives, representatives, dealers, salesmen could learn much more about: consumer psychology; the elementary principles of heating and combustion—and be able to demonstrate proper usage; the trends in building, design, operation; ways and means of creating the highest possible standards of customer relationships.

The Dealer's Job—

With so many domestic fuel users wasting one ton of coal out of every five they buy, or a similar percentage of oil —half of which could be saved with little or no investment in critical materials—there is every reason for the heating industry to increase its educational efforts and open the way to a sizeable volume of replacement heating business as soon as the war is over. It is the heating dealer's opportunity today, to:

1. Cultivate building owners, real estate interests and others to sell them on plant inspection, cleaning and repair service.
2. Get a folder or folders on "heating service" into the hands of every possible fuel user.
3. Get some pertinent advertising and publicity into the local newspapers.
4. Publicize the authoritative and specific suggestions of the War Service Committee of the ASHVE on how to prevent needless heat losses and fuel waste.
5. Take advantage of the telephone and talk to every customer.
6. See every customer or prospect possible, personally.
7. Get the story of the present fuel and heating situation, cleaning and inspection service to local luncheon clubs and other organizations.
8. Check with one's sources of supply as to spare parts, repairs, replacements, and the sale of accessory equipment. Create a prospect file on replacement business.
9. Make better salesmen out of every employee (this takes training, but we will never get maximum results without it).

Some cleaning and other service work may be a nuisance sometimes, but it pays. How much business the heating industry does in the next few years, is going to depend on how intelligently and aggressively we go after such service activities. "The Lord gave us two ends . . . one to sit on, and one to think with. Our degree of success depends upon which one we use most."

Nine out of ten fuel using plants need attention—inspection, cleaning, adjustment, alterations, repairs—but they are not getting such attention because the owners haven't been sold. So, "education" and selling them is the engineer's job today. It will help win the war, too.

People are Interested—

Today—customers are tremendously interested in their heating problems—even if many haven't paid any too much attention to them in the past.

Note the sales of insulation the past few years. What else indicates as much interest in (1) getting greater comfort—getting sections of the house warm that were difficult to heat; (2) preventing needless fuel or heating waste; (3) cutting heating costs?

But the exaggeration and misrepresentation that have accompanied many sales efforts on fuel or heat saving items have made some people a bit dubious. Therefore one of the first jobs is to bring home to fuel users a clear conception of the fundamental factors that affect their comfort or heating results. To help create in the minds of more home and building owners a consciousness of their responsibilities and opportunities in improving comfort, preventing heat losses and fuel waste, it should prove helpful to get the following fuel user's pledge into the hands of every possible domestic fuel user:

Fuel User's Pledge

1. **See that my heating plant is clean and kept clean—that it is properly operated.**
2. **Have the heating system inspected.**
3. **Have recommended repairs or alterations essential to efficient operation of the heating equipment made as soon as the dealer can do so.**
4. **Put in insulation, storm windows and weatherstripping if it hasn't already been done.**
5. **Control temperature, not waste heat—regulate it.**

Such a pledge can be reproduced, distributed, and publicized in many ways to distinct advantage.

Even if only a few "do anything about it," you have none the less brought some important factors that affect heating comfort to the attention of the others also—you have thrown directly into their hands, something of the responsibility for what they get out of their heating facilities or the fuel they buy.

Most home or building owners will appreciate the good faith, interest, and patriotic motives of such efforts to help them improve their heating results, prevent heat losses and eliminate fuel waste.

Discussion on Mr. Richmond's address was postponed in order that it might be included in discussion of the subjects which were to be introduced by the members of the Panel on fuel conservation.

Panel Discussion

Following a brief recess, Chairman Winslow introduced Past President M. F. Blankin, Philadelphia, to lead the panel discussion. Mr. Blankin introduced the following members of the Panel: R. F. Connell, Detroit; R. C. Champlin, Detroit; M. W. Crew, Milwaukee; C. C. DeWitt, Lansing, and John James, Cleveland.

Professor DeWitt, Michigan State College, representing the National Fuel Efficiency Council and Coordinator of the Greater Lansing Area, presented the reasons for the anticipated fuel shortage during the coming winter. He stated that the average householder probably would receive 75 to 90 per cent as much coal during the coming season as in the past. Among the

reasons for this reduction he mentioned some of the following: The armed forces and war industries require 6 per cent more fuel; railroads require 10 per cent more fuel; and transportation facilities available for moving fuel would be decreased through the necessity for moving more war goods. He stated that immense quantities of petroleum, gas, and coal were being diverted for Army and Navy use and to supply temporarily certain liberated areas.

The national stockpile of coal above ground was assumed to be less than 30 days ahead of solid fuel demands. The anticipated demand for bituminous coal for the current season was given as 626,000,000 tons compared to an anticipated production of 596,000,000 tons. The difference between the two indicated an anticipated shortage of 30,000,000 tons. Anthracite coal anticipated requirements were 65,000,000 tons, which was about 8,000,000 tons above the anticipated production of 57,000,000 tons. The total shortage of anthracite and bituminous was therefore given as 38,000,000 tons and it was expected that the whole nation must keep going and keep warm on a third of a ton less fuel per inhabitant than had been available during the past year.

Professor DeWitt explained the functioning of the National Fuel Efficiency Council. It was organized from the ranks of patriotic business and technical men serving without pay. The Council in cooperation with the Department of the Interior and through the agency of the Bureau of Mines had inaugurated a National Fuel Efficiency Program, which was expected to reduce fuel consumption to the quantity available. The National Fuel Efficiency Program was only slightly concerned with the average householder's use of fuel. Its field of activity included all users of fuel beginning with four apartment buildings and extending to the largest commercial user.

In organizing the National Fuel Efficiency Program each State is divided into areas centered about large industrial cities and a coordinator is appointed for that area. The supervising engineer, Thomas C. Cheasley, selects coordinators for the fuel area and the engineers at the Bureau of Mines, Pittsburgh, act as liaison officers between the coordinators and the supervising engineers. It is the duty of the area coordinators to organize an advisory committee which, with the approval of the coordinator, selects regional engineers who operate on a volunteer basis.

The regional engineers call upon the fuel users to enroll in the fuel saving program. The fuel user is asked to sign a pledge and this pledge eventually is sent to the National Fuel Efficiency Council in Washington.

Advice for fuel users has been prepared in the form of 75 different types of information sheets referring to equipment affecting the quantity of fuel used. The assistance of smoke commissioners and smoke abatement engineers from all parts of the country had already been promised and much assistance was expected through the wholehearted cooperation of engineering societies.

Emphasis was placed upon the voluntary nature of this fuel saving program which was sponsored and supported by industry.

Chairman Blankin thanked Professor DeWitt and expressed the conviction that the ASHVE was enthusiastically back of the program in which many members were serving as regional engineers and coordinators. He urged Society members to consult local coordinators and to offer their services.

Mr. Connell was presented as the speaker who would discuss the subject of the *Heat Generator*. The first point made by Mr. Connell was that the engineer would probably be faced with the problem of obtaining fuel savings by using the existing equipment, rather than by substituting more efficient appliances. Much could be done by repairing fire doors, smoke hoods, control equipment, etc., and eliminating air leakage. In the examination of boilers, for instance, it would be expected that in some instances incorrect assembly of sections would be discovered as a cause of wastage of fuel. Instances were cited in which incorrect sections had been used for repair purposes with the result that flue gases had been able to short-circuit some of the flues. Reference was made to the opportunity for saving fuel by insulating the boiler and piping, which in certain sections of the country were usually left uninsulated.

Mr. Connell felt that the need for fuel conservation would promote a better understanding and appreciation of the type of equipment required for efficient operation and that this interest would be mutually advantageous to the purchaser and manufacturer.

Chairman Blankin mentioned that unclean flues could cause an efficiency loss of 6 per cent. He pointed out that if half of this could be saved, it would amount to 120,000 carloads.

The next speaker was Mr. James, whose subject was *How Can the Stoker Industry Assist in Saving* 38,000,000 *Tons of Coal in the Coming Heating Season?* Mr. James proposed three methods in which the stoker industry should be particularly interested: (1) The conversion of hand-fired installations to stoker operation in order to overcome manpower shortages, enable the use of a local coal which might be of an inferior grade, and to reduce smoke difficulties. He pointed out that by use of automatic firing and increased plant efficiency there might also be obtained an accompanying increased steam output without the necessity for increase of boiler capacity. (2) Modernization of existing stoker installations was mentioned as a second way in which the stoker industry could assist in saving fuel. Mr. James stated that of the 1,000,000 stokers now sold, 75 per cent were of domestic or residential types and 25 per cent were of commercial or industrial sizes. (3) A general check-up of the heating plant efficiency was advocated as a third method of saving fuel.

Chairman Blankin introduced Mr. Champlin, to whom the subject, *Ways and Means of Utilizing Oil Efficiently*, had been assigned. He stated that any fuel conservation program must be based upon three main factors: (1) combustion efficiency; (2) heating plant efficiency; (3) conservation of heat loss from the building. He discussed the first two items because they were particularly applicable to the present panel discussion.

Under combustion efficiency Mr. Champlin stressed the need of determining the rate of oil supply required for a given installation and then making the air adjustments correctly to obtain a minimum flue gas loss. He mentioned the importance of a draft regulator to prevent variation in excess air. The importance of pre-

venting leaks of air into the appliance or into the combustion chamber was explained. Prevention of soot formation and the cleaning of scale, rust, sediment, etc., from heating surfaces were mentioned as important items in improving efficiency.

Mr. Crew, chairman of the Fuel Conservation Council for War of the Automatic Control Industry, discussed *Fuel Saving as Effected by the Use of Automatic Controls.* He reported an estimate that proper control equipment could save 6,000,000 tons of coal. This estimate was based upon studies of records of the *National Warm Air Heating and Air Conditioning Association,* the *Stoker Manufacturers Association,* and the *National District Heating Association.* He mentioned that the saving could be obtained by manufacture of 375,000 damper regulators, 400,000 barometric controls, 35,000 sets of heating system controls, and 30,000 sets of commercial and industrial boiler controls. It was estimated that the production of this equipment could be obtained by adding only 735 people to those presently engaged in making controls. About 50 or 60 of the 735 people required would need to be skilled mechanics. It was expected that a saving of 1,200,000 miner man days would be obtained because of the reduction in fuel requirements resulting from the use of the proposed control equipment. Mr. Crew stated that the War Production Board had granted material for the production of the control equipment.

It was Mr. Crew's estimate that 22 per cent of existing stoker installations in the United States were fully equipped with draft control. He reported a survey of 112 stokers in one city which showed a flue gas temperature of 425 to 875 deg, with an average of about 700 deg. Mr. Crew then referred to the publicity program which would be used to make owners aware of the need for automatic controls as fuel saving devices.

Chairman Blankin announced that the meeting was then open for discussion from the floor.

H. M. Nobis, Cleveland, related his experience in connection with one installation in Cleveland in which it had been possible to reduce fuel consumption from 5100 tons to 875 tons in one year. The savings were obtained by eliminating leaks in boiler settings, correcting damper operation, correcting conditions in the feed water heater, and stimulating the operating crew to obtain a high operating efficiency.

E. E. Dubry, Detroit, pointed out that fuel would be saved by what happened in the boiler room after the pledge had been signed. He pointed out that firemen have definite ideas about the condition in which they prefer to keep a fire and that, in order to teach them to manipulate fires properly, it is necessary to educate them in the use of simple equipment for determining proper combustion conditions.

John Howatt, Chicago, emphasized the importance of preventing heat loss up the stack. In being responsible for operation of about 800 boilers, he had found it worthwhile to provide the operators with Orsat analysis apparatus and flue gas thermometers. He referred to the Society's participation in the oil rationing program and felt that pride could be taken in the work done.

Mr. Howatt stated that there was need for authentic information regarding the actual amount of fuel available. Statements had been made that the production of coal per miner was less than formerly due to increased age of workers, that coal would probably be needed for shipment to Europe, and that the British fleet which might be operating in the Pacific soon would require a considerable amount of U. S. coal. With decreased cutting of wood because of lack of manpower, 15,000,000 tons of coal would be required as a substitute for wood.

Mr. Howatt stated that the fuel saving program was so huge that a few hundred men would accomplish very little. The need would exist for thousands and he urged everyone capable of helping to enlist in the work.

H. E. Lewis, Toledo, pointed out that insufficient attention was being paid to efficient utilization of the heat produced. He proposed an increase in emphasis on insulation of industrial equipment. Due to the great proportion of fuel used in industrial processes, the opportunity for quantity savings would be greater and consequently he advocated increased attention to savings that could be made by large users of fuel.

Chairman Blankin asked Mr. Richmond for statistics on the relative consumption of coal by industrial and domestic users.

Mr. Richmond gave the proportion of coal used as follows: 170,000 manufacturing industries 20 per cent; railroads 25 per cent; greenhouses, laundries, dairies, apartment houses, and homes 20 per cent; coke and steel industry 35 per cent. The annual production of bituminous coal was expected to be 600,000,000 tons. In regard to production per man, he stated that in certain strip mines 16 tons of coal were produced per man per day.

Chairman Blankin called upon B. F. McLouth for some comments on the fuel conservation program conducted by the U. S. Army.

Mr. McLouth stressed the value of educating the men who were operating fuel burning equipment. He showed how proper training and comparison of results obtained in various camps had stimulated fuel saving throughout Army posts with savings of 25,000 to 50,000 tons annually in large camps.

R. K. Thulman, Washington, D. C. suggested that much fuel had been saved by the use of insulation, but that the reduction of the heating load effected by use of insulation had in some cases caused a heating plant to be too large. He felt that the insulation industry should, therefore, be interested in providing proper operating instructions for heating plants.

E. K. Campbell, Kansas City, suggested the use of economizers installed in the outlets of boilers in cases where flue gas temperatures were too high. He cited an instance in which such an economizer supplied air to heat a basement auditorium of a church.

He also suggested that proper air circulation could frequently save fuel by distributing the heat where needed and thereby eliminating overheating of some parts of the building in order to heat others adequately.

A. R. Frantz, Lansing, Mich., gave his opinion that air filters if not replaced or renewed when dirty would cause a considerable waste of fuel.

L. E. Seeley, New Haven, gave his experience in cleaning boiler heating surfaces by using a water spray applied with the burner in operation and expressed the opinion that this method of cleaning produced a very clean surface and eliminated the necessity for brushing or scraping.

Chairman Blankin thanked the members on the panel, after which Vice-Pres. C.-E. A. Winslow took charge of the session.

On motion of Mr. Blankin, seconded by Mr. Frantz, it was voted that the Resolutions Committee prepare appropriate resolutions endorsing the National Fuel Efficiency Program.

The meeting adjourned at 4:30 p.m.

Third Session—Tuesday, June 20, 9:30 A.M.

The third session was called to order at 9:30 a.m. in the ballroom by 2nd Vice-Pres. A. J. Offner, New York, who announced that the registration at that time included 197 members, 49 guests, and 80 ladies, making a total of 326.

W. F. Wells, Philadelphia, presented his paper, Air Disinfection in Ventilation (published in June 1944 Journal Section, Heating, Piping & Air Conditioning).

Dr. C.-E. A. Winslow stated that the development of sanitary ventilation was one of the most significant happenings in public health during the past 25 years and that progress was due chiefly to the efforts of the author. He suggested that it was time to put sanitary ventilation on a practical design basis and expressed the hope that the Technical Advisory Committee on Air Sterilization and Odor Control would proceed to do six things: (1) obtain agreement on a method of determining the number of streptococci present in air; (2) establish a standard of performance and state the permissible number of streptococci per cubic foot of acceptably clean air; (3) establish the concentration of streptococci which may be found in various types of occupied rooms under average and under extreme conditions such as obtained during a cold epidemic; (4) establish the number of air changes required to reduce the various degrees of pollution to an accepted standard by means of outside or purified, recirculated air; (5) establish a basis on which to determine the cost to obtain the desired standard condition by the use of ultra violet light or a combination of ultra violet light and air change; (6) obtain the cost of obtaining standard conditions by use of aerosols sprayed into the air for comparison with cost to produce the same standard condition by means of proper air change and ultra violet radiation.

W. A. Danielson, Memphis, paid tribute to Dr. and Mrs. Wells, whom he referred to as modern Curiés. He referred to a hospital installation of sterilizing units in ducts and over an operating table and mentioned that the lamps in the ducts gave much trouble, because provision had not been made for easy access for cleaning of the lamps. He also inquired whether any progress had been made in the use of sterilized air to fight tuberculosis.

Dr. Wells expressed his gratitude for the kind remarks made by Dr. Winslow and General Danielson. He felt that it had been possible to carry on the work largely because of the recognition that had been accorded it by such men.

He confirmed the importance of cleaning lamp bulbs because ultra violet light is deeply sensitive to the very thinnest layers or very smallest particles of dirt. Cleanliness is, therefore, extremely important in order to prevent a drop in efficiency.

Dr. Wells stated that a recent comprehensive paper published in the *Journal of Experimental Medicine* showed conclusively that ultra violet light had been effective in preventing cross contamination in tuberculosis. Results reported in the paper supplemented work which had been done in the laboratory by the author and demonstrated that tuberculosis could be prevented from spreading in animal rooms. The author stated that owing to the toughness of the tuberculosis bacillus, publicity had not been given to the experiments until definite conclusions could be drawn.

A. D. Brandt, Chicago, presented an abstract of his paper, Industrial Exhaust Ventilation in Industrial Hygiene (published in July 1944 Journal Section, Heating, Piping & Air Conditioning).

L. T. Avery, Cleveland, commenting on the paper, stated that in designing exhaust systems it was equally important to design for an equivalent air supply in order to control the quality and quantity of the supply and the direction of the air currents. He stated that outside air is sometimes as bad as the air exhausted.

T. H. Mabley, Detroit, agreed with Mr. Avery regarding the importance of providing an adequate supply of air. He stated that provision for exhaust alone sometimes interfered with proper operation of the heating system and, therefore, it was important that exhaust systems should be designed by engineers familiar with design of heating and ventilating systems.

W. N. Witheridge, Detroit, stated that industrial ventilating systems should always be installed by engineers. He estimated that one-third of the failures in the exhaust systems were due to failure to design an adequate air supply. Necessity for control of the atmosphere had been brought about by an increasing knowledge of the effect of atmospheric contamination on health. Since proper ventilation is effective in preventing occupational diseases in industry, engineers and health officials should cooperate in the design of proper ventilating systems.

W. A. Evans, Cleveland, expressed his appreciation to Dr. Brandt for the excellence of the paper.

Mr. Evans referred to the danger of exposure to chromic acid fumes which first attack the bridge of the nose in persons breathing it. He recommended application of the exhaust duct to the center of the tank (rather than as shown in Fig. 3 of the author's paper), in order to increase velocities by four and to reduce the amount of air required, the friction, and the cost.

L. G. Miller, Lansing, suggested that in Table 1 some allowance should be made for temperature of the vats, because a high temperature would increase the kinetic energy of the molecules and thereby make capture of the contaminant more difficult.

Dr. Brandt was in agreement regarding the importance of an air supply equal to or somewhat in excess of the exhaust and pointed out that in most of his work a supply of properly conditioned air was usually recommended.

Referring to Mr. Evans' remarks the author stated that wherever possible flanges should be used on all types of suction openings. Lowering of the slots would improve performance and have an effect similar to that of a flange.

Chairman Offner then called upon B. H. Jennings, Evanston, who presented the paper, The Use of Glycol Vapors in Air Sterilization and the Control of Air Borne Infection, which he prepared with Edward Bigg and F. C. W. Olson (to be published in September 1944 Journal Section, Heating, Piping & Air Conditioning). A telegram was received from W. L. Fleisher, New York, regretting his inability to be present and expressing his intention to submit a discussion which could be incorporated in the Society's Transactions.

Past President M. F. Blankin announced that applications for Chapter charters had been received and approved for a Rocky Mountain Chapter to be located at Denver, and a Memphis Chapter to be located in Memphis, Tenn. The charter meetings for both Chapters would be held in the early Fall, he stated. Mr. Blankin also reported that the Organizing Committee at Columbus, Ohio, had sent a telegram stating that an application for a Central Ohio Chapter was being mailed.

The next paper presented was The Engineering Control of Some Solvent Hazards in War Industries, by S. C. Rothman, New York (published in June 1944 Journal Section, Heating, Piping & Air Conditioning). Owing to the absence of Captain Rothman on military duty, an abstract of the paper was presented by Carl H. Flink, Technical Secretary of the Society.

Mr. Avery remarked that heating and ventilating engineers are concerned not only with air temperatures, humidity, and quantity, but also with air quality. In industrial

application of air conditioning it is important to determine whether solvents are to be used and, if so, to know what the limits of permissible contamination are and to provide control measures.

Mr. Avery cited an installation in an industrial plant in which air conditioning was designed for 78 deg dry-bulb temperature and 40 per cent relative humidity. The given air conditions were selected to prevent tarnishing of bearings. Due to the use of carbon tetrachloride, gasoline, and naptha in the room, it was found that the air introduced was not sufficient to prevent excessive contamination. The system was originally designed for 17,000 cfm of which 12,000 cfm was recirculated. A reduction of contamination was obtained by introducing 12,000 cfm of outside air, but it was not effective in summer because of the difficulty of maintaining 40 per cent relative humidity. Instead of installing additional cooling and dehumidifying equipment for the purpose of reducing the humidity, the problem was solved by passing the recirculated air through activated carbon.

In another installation in a factory manufacturing penicillin air was contaminated by the use of amyl acetate. It was found that dilution with outside air was satisfactory to reduce contamination. The air was introduced at low velocity at one end of the room and was exhausted at the floor level at the opposite end.

The meeting adjourned at 11:45 a.m.

Fourth Session—Tuesday, June 20, 1944, 2:00 P.M.

Pres. S. H. Downs, Kalamazoo, presided at the fourth and final session. He announced the registration of 340 at 2:00 p.m. and anticipated that the attendance would reach 350 before the session had been concluded.

The first paper, Some Effects of Attic Fan Operation on Comfort, by W. A. Hinton and W. G. Wanamaker, was presented in abstract by Professor Hinton (published in May 1944 Journal Section, Heating, Piping & Air Conditioning).

T. T. Tucker, Atlanta (written): The authors have in this *extended investigation* again produced outstanding data. These data possess a startling degree of practicality.

There is one procedure which perhaps should be explained. Why were readings taken 30 in. above the floor? Why were they not taken at some other elevation such as 60 in. above the floor?

From the author's explanations of the differences noted in air changes and air velocities in various rooms it would appear that best comfort results from attic fans can only be procured when external surroundings are properly weighed. These must include: (1) Orientation of the building. (2) Location with respect to immediate geography. (3) Prevailing winds. (4) The proximity and location of adjacent buildings. It would materially add to the usefulness of this paper if the authors would present us with succinct conclusions on these points.

It is a known fact that a well insulated house, with proper shading devices over the glass areas, will in the Atlanta area start its cooling cycle many degrees below that of a house such as the test house here shown. It would appear therefore that the operation of an attic fan under such conditions would be entirely different from that shown by this paper. For example, the optimum time of day for starting and stopping the fan would certainly change. In view of the ever increasing use of good insulation and proper shading devices I wonder if the authors intend to investigate these in combination with the attic fan?

It can be seen from Fig. 2 that when the fan is first turned on it draws into the house air at a higher temperature than the air displaced. Would it be reasonable to assume that the initial cooling effect is procured by exhausting the hot air from the attic? I wonder if best results could be obtained by displacing the attic air only until such time as the temperature of the outside air had dropped below that of the inside air? Do the authors have any data on this method of operation?

C. F. Malley, Detroit, cited the beneficial effect of large quantities of air in producing a cooling effect, but he felt that air velocities of 200 to 400 fpm would undoubtedly produce uncomfortable drafts.

He referred to the possibility of dust trouble arising from use of large quantities of air.

G. L. Tuve, Cleveland, referred to the difficulty of measuring air velocity and the discrepancy likely to arise from use of different instruments by various investigators. He suggested that the selection of the type of instruments for measuring velocity should be given careful consideration.

B. H. Jennings, Evanston, inquired about the quantity of dust introduced by the large volumes of air and also asked about the power requirement of the fans.

Authors' Closure: Professor Hinton in reply to Mr. Tucker's comments acknowledged that the air velocities in the home were influenced by the location of the house and by the objects which surrounded it. He stated that temperature measurements had been taken at a 30-in. height because it was more nearly the average temperature surrounding a seated person.

While the effect of a fan drawing air only through the attic, in which an air temperature of 120 to 140 deg might be reached, would undoubtedly be beneficial, the author stated that no tests had been conducted to determine the results obtainable under these conditions.

The author also stated that the heated thermocouple anemometer used in the tests was obtained from Prof. A. P. Kratz, University of Illinois, who also supplied the calibration of it. It was used because readings could be obtained more quickly than would be possible with the Kata thermometer.

Replying to Professor Jennings, the author stated that dust introduced by the air was very troublesome and that such trouble would be expected in any locality having dusty outside air.

Power requirements were not measured in the tests, but the author suggested that considerable data on this subject could be obtained from Bulletin 52, Installation and Use of Attic Fans, published by the A. and M. College of Texas.

Owing to the inability of the authors to be present, the next paper, Train Piston Action Ventilation and Atmospheric Conditions in Chicago Subways, by W. E. Rasmus and Edison Brock (see p. 495), was presented in abstract by Mr. Flink.

As no discussion was offered, President Downs introduced E. R. Ambrose, New York, who presented an abstract of the paper, Description and Performance of Two Heat Pump Air Conditioning Systems, by Philip Sporn and himself (published in June 1944 Journal Section, Heating, Piping & Air Conditioning).

Mr. Avery expressed particular interest in the paper because it related to summer air conditioning. Referring to a statement made at a previous Society meeting that residential heating systems of the future would require 30,000 to 50,000 Btu per hour input for heating, Mr. Avery stated that a 3 to 5 ton refrigeration machine would be adequate to cool such homes, if efficiently insulated, in the summer and provide heat in winter, if a free source of heat for the refrigerating machine could be found for winter use.

Certain types of plants such as cold storage, dairies, ice cream plants, and skating rinks offer opportunities for reverse cycle heating because the refrigeration capacity required is greater than that required for heating.

Mr. Avery stated that if there should be an extended use of food freezing locker installations in homes, clubs or small hotels, such installations might provide a source of refrigeration for heating purposes.

It was felt by Mr. Avery that there were many cases in which refrigeration could be used economically for heating purposes.

Mr. Avery made the comment that the heating and ventilating engineer must now be also a refrigeration engineer and an industrial hygienist.

Authors' Closure: Mr. Ambrose extended an invitation to Society members to inspect the installations described in the paper at any time.

President Downs announced that the presentation of technical papers had been concluded; he also stated that the total registration had reached a figure of 351, which included 206 members, 61 guests, and 84 ladies.

Summing up the activities of the Semi-Annual Meeting, President Downs stated that the meeting had been successful and that everyone attending had undoubtedly enjoyed the meeting and learned something from attendance at the technical sessions as well.

K. C. Richmond read the following report of the Resolutions Committee and on motion of W. A. Russell, seconded by E. R. Ambrose, it was adopted unanimously.

Resolutions

Whereas, the Semi-Annual Meeting 1944 of The American Society of Heating and Ventilating Engineers has been an outstanding event in the City of Grand Rapids, Mich., June 18 to 20.

Therefore, be it resolved, that an expression of thanks and appreciation be adopted by this meeting and be spread upon the minutes of the Society and copies thereof be transmitted to each of the persons and agencies who have contributed toward making this meeting so enjoyable for the members of the Society who attended.

To H. D. Bratt, president, and C. H. Pesterfield, immediate past president, of the Western Michigan Chapter and the Chapter members for the capable manner in which they fulfilled their positions as hosts.

To Chairman Thomas D. Stafford and his Committee on Arrangements, whose careful planning and outstanding efforts have been shown in every detail of this meeting.

To Mrs. O. D. Marshall and her Committee who did such splendid work in entertaining the ladies.

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To the Authors and Panel Speakers at technical sessions for their instructive papers and able presentations.

To the newspapers and trade publications whose columns have given advance notices and daily coverage to the Semi-Annual Meeting.

To the Pantlind Hotel employees who contributed to the success of the meeting and comfort of the members under difficult war conditions.

To the Grand Rapids Chamber of Commerce for their cooperation and assistance.

To the Past Presidents and to our Life Member, L. W. Millis, of Kansas City, for their continued interest and attendance at this meeting.

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To Dr. M. M. McGorrill for his very inspiring and timely talk on Human Relations.

To the members of the Society who are in the armed forces and others who are giving their services in many ways for the successful prosecution of the war.

To the Banquet Committee in anticipation of the pleasure that we will derive from the Semi-Annual Dinner tonight and the entertaining talks by Mr. Roger Allen and Prof. E. C. Prophet, and

Finally, to every member of the American Society of Heating and Ventilating Engineers who has attended this meeting for his loyalty and support.

Be it further resolved, that the members of this Society pledge their support to the Government in its National Fuel Efficiency Program to expedite the war effort by helping to prevent the needless waste of heat and power.

Respectfully submitted,

RESOLUTIONS COMMITTEE,
K. C. Richmond, *Chairman*.
R. L. Blanding.
E. C. Evans.

The meeting was adjourned at 3:30 p.m.

Research Committee Plans Active Progam

Research Finance

Chairman Tuve announced the formation of a Research Finance Advisory Committee consisting of five (5) members of the Committee on Research, Messrs. C. M. Ashley, W. E. Heibel, L. P. Saunders, T. H. Urdahl and C.-E. A. Winslow—together with five (5) members of the Council—Messrs. L. T. Avery, M. F. Blankin, W. A. Danielson, E. N. McDonnell and B. M. Woods. This Committee, together with Messrs. A. V. Hutchinson, Cyril Tasker, Professor Tuve, and Mr. Walker, met on Sunday evening and a very spirited and helpful discussion of research program, publicity and finance took place. As a result, the decision was made that the financial appeals to industry should be handled from the Research Laboratory in close cooperation with the New York Office.

The focal point of research activities at Grand Rapids was a booklet entitled *Research Projects of Importance to the Industry* which had been prepared on the instructions of the Executive Committee of the Committee on Research. It contained details of 28 research projects suggested by Technical Advisory Committees and approved by the Executive Committee. The booklet had been prepared in mimeographed form rather than printed form so that members could criticize both the method of presentation and the technical aspects of the various projects. It will later be printed and will include other projects considered and approved at the Grand Rapids meeting. The booklet was in two parts: Part 1, entitled *Why These Projects Are of Importance to the Industry* consisted of a non-technical presentation of the reasons underlying each particular research project, while Part 2, entitled *How These Projects Have Been Organized and Planned*, gave fairly comprehensive technical data on:

1. The reason for undertaking the project.
2. The specific objects to be determined.
3. The type of research and
4. The general methods of attack.

The Executive Committee was particularly gratified with the reception given to this booklet and, as a result of many requests, copies of the booklet were displayed near the registration booth, and members and guests were asked to sign their names if they desired copies to be sent to them. Out of a total registration of 205 members and 62 guests attending the technical sessions, over 150 requested copies, a most encouraging indication of the interest of the membership in the Society's research work.

Research Committee Meeting

At a meeting of the Committee on Research which was held on Tuesday afternoon, the Director made a report to the Committee on the activities since the January meeting, presented the financial statement, and requested certain changes in the budget which had become necessary on the removal of the Laboratory to Cleveland and the expanded research program. He reported that all major structural changes to the building at Cleveland had either been made or would be completed within the next three or four weeks, and that a nucleus staff had been engaged and had already settled down into a good working team. The Laboratory had been equipped with the necessary tools, benches, etc., and it was now fully prepared to commence work on actual research investigations.

The main part of the meeting was concerned with a discussion of the research booklet already mentioned and of methods of publicizing and financing the considerably expanded research program which had been approved by the Committee at its January meeting. The active interest displayed in research is one of the most encouraging signs that the Society is alive to its responsibilities and prepared to play its full share in the solution of the many problems still facing the industry.

The Chairman stated that both he and the Director had been extremely gratified at the number of visitors who had come to the new Research Laboratory to discuss problems of the industry. He pointed out that, in common with many other organizations, we are severely handicapped by the shortage of trained technical personnel and appealed to all members of the Committee and of the Society to advise him of any suitable personnel with research experience who might be interested in a new assignment and willing to share in the responsibility of getting our research program into high gear. The Chairmen of the Technical Advisory Committees who were

present at the Grand Rapids Meeting attended the Committee on Research meeting and participated freely in the discussions with the result that many valuable suggestions were received.

Cooperative Projects

Renewal of the following cooperative contracts was approved by the Committee on Research at this meeting:

University of California: *a.* Cooling Tower Project; *b.* Panel Heating Project.
Cornell University: Periodic Heat Flow through Building Walls.
Case School of Applied Science: *a.* Heat Transfer Coefficients of *Freon* Refrigerants; *b.* Air Distribution Project.
Oregon State College: Heat Losses through Wetted Walls.
University of Pennsylvania: Study of Psychrometric Data.
University of Minnesota: *a.* Air Cleaning Project; *b.* Analysis of Comfort Data.

A new contract was approved with the Agricultural and Mechanical College of Texas covering studies in pipe friction and turbulence due to circulating pumps. Chairman Tuve announced that on behalf of the Executive Committee he had approached a number of other institutions with whom we had not heretofore carried out cooperative research work and that he was gratified with the response from these institutions and hoped to be able to continue the discussions with a number of them and suggest in the relatively near future an expansion of our cooperative research work. The Committee approved the appointment of a subcommittee to study the question of the relationship between the Society and cooperative institutions in the matter of patents resulting from cooperative research work.

Research Library

The Committee on Research approved the proposal to establish at the Research Laboratory the John R. Allen Memorial Library, the intention being that all of the volumes in the library should bear a suitably prepared bookplate indicating that they were part of this memorial library. The library would be set up to commemorate John R. Allen, the first director of the Research Laboratory, who died while in its service, and who is affectionately remembered by many of the older members of the Society.

The Committee on Research approved a proposal that the Director assume membership of a number of other technical societies so that he may attend their meetings as a member while representing the Committee on Research of the Society. It was also approved that all technical publications from such societies should be placed in the library of the Research Laboratory.

Get-Together Luncheon

A Get-Together Luncheon was held in the Grille Room at 1:00 p.m. with H. D. Bratt, president of Western Michigan Chapter, acting as chairman. Owing to the absence of Hon. George W. Welsh, Mayor of Grand Rapids, who was attending a Mayors' Convention in Canada, a welcome was extended to the members of the ASHVE by City Manager Walter W. Sack. Mr. Sack spoke about the importance of the many questions which the ASHVE had planned to consider at this meeting and also outlined some of the opportunities for enjoyment of the vicinity of Grand Rapids and the State of Michigan for recreational purposes.

The principal speaker at the luncheon was Dr. M. M. McGorrill, conductor of the Faith for America radio program on a number of Michigan stations, whose subject, *What Makes an Engineer Tick* (see p. 492), proved to be a very interesting outline of the factors which enable engineers to work effectively with their associates and with those who may be in their charge.

Semi-Annual Dinner

The Semi-Annual dinner started promptly at 7:00 p. m. in the ballroom of The Pantlind, with the singing of the *Star Spangled Banner*, and the invocation was given by Dr. M. M. McGorrill.

T. D. Stafford, Chairman of the Committee on Arrangements, welcomed the 250 members and guests and introduced Brig. Gen. W. A. Danielson, U.S.A., for the presentation of a tribute to the 369 Society members in the armed services.

Tribute to Armed Forces
By Brig. Gen. W. A. Danielson

Fellow members and guests: It is fitting that we should pause for a moment, at the beginning of the end of the most terrible war in the world's turbulent history, to pay respect to those who have changed from citizens to active members of the armed forces. To me, it is an especial honor that I am privileged to voice this tribute. As a regular Army officer my status is different from the civilian soldier, but perhaps my long service makes me feel more keenly the justification of this tribute. I am humbled by my inability to find words that will adequately express this tribute. My heart is overflowing, and yours, too, I know, and words do not satisfy.

Members in uniform of this Society of ours are doing their share wherever the uniform is worn; many of these brothers, sons, fathers, in the steaming jungles of Burma, in Italy, on the deserts of Iraq, on malaria-infested Guadalcanal, and still others have lived so far through the battle astride the Potomac. Whether it be battleship or battleplane, tank or submarine, anti-aircraft gun or laundry unit, in the fighting lines or the supply echelons, we find members of the Society doing more than their bit, as would be expected.

Each one of the almost 400 members in service—about 15 per cent, one out of every six or seven on our roster—is entitled to be named individually. I owe it to them, but you have already included their names in the Society Journal, which is more permanent than my fleeting mention could be.

In going over this list I came across the names of old friends of yours and mine, and have heard something of them from you. The former president of the Kansas City Chapter, D. D. Zink, is a Lieutenant Colonel on General Staff duty. Captain H. K. McCain is now in the Quartermaster's Corps. A. E. Reif is the Fighting Colonel of the 74th Infantry. Captain A. E. Stacey, Jr., controls the flow of materials for destroyers and scouters and landing craft in the Navy. Captain T. H. Werner is in the Signal Corps. Sergeant A. E. Kurtz, who was for seven years with the laboratory in Pittsburgh, is now on the windswept and isolated Aleutians. J. K. Gonzales is a pilot in the Air Corps. Dr. M. B. Ferderber is now a captain in the Medical Corps. In the Canadian and British Forces, doing their bit, among others, are Lieutenant Colonels J. B. Bishop, J. H. Fox, L. W. Norfolk, and Bombardier Harry Richardson.

The various uniforms have brought the war to this meeting. I know that you all enjoyed talking with our former Director of the Laboratory, Commander Ferry C. Houghten. Commander T. H. Urdahl has left, but Lieutenant-Commander E. A. Queer, Tom's righthand man, is still here. You listened to the interesting paper by Major Brandt. Lieutenant Jack Everetts just returned from the Southwest Pacific.

And now I come to a tribute for service that I wish were otherwise. Captain John Pryke, of the British Army, was made a prisoner of war in North Africa. Two of our brother allies have made the supreme sacrifice: Wing Commander Phil H. Foster, R.C.A.F. and Flying Officer H. K. Temple of the Royal Air Force, were killed in action. We extend our sympathy to those near and dear to them, but we are proud of them. They gave their all that our cause might prevail.

Yes, we sincerely pay our tribute to those in the armed forces, but it must be more than words. We must each do our part in solving the problems here at home that will follow the end of hostilities. Remember, always, that we are first American citizens and then engineers.

It was in large part the failure of the German business man to enter into government, or politics, as we call it,

that brought Hitler into power and this war to us, a vacant chair in many homes, perhaps your home. The foundation of this power was laid just after Versailles in the dissatisfaction of the young German Army officers, Major and below, that had returned to no future at home, and often starvation. They had the disintegrating comparison with the years of position, ample food and steady salary in wartime.

Unless we solve the problems ahead wisely and soundly, this sincere tribute to our armed forces may be scorned tomorrow. We each of us must not fail him or our country. With God's help, may we keep it the Land of the Free, and thus pay lasting tribute to our members of the armed forces.

Chairman Stafford introduced the toastmaster Roger Allen, Grand Rapids architect and well-known columnist on the Grand Rapids Press. Mr. Allen acknowledged the chairman's introduction and said it reminded him of one of those bustles the ladies used to wear. In other words, it was a fictitious tale based on a stern reality. The stern reality is that I am an architect and a columnist and the fictitious part of it is that I am going to engage in any unequal contest in egg-laying either with an ostrich or Mr. Stafford.

However, I must say that the invitation that Mr. Stafford gave me to appear here this evening was pleasanter than an invitation that a State official, who is a friend of mine, got some weeks ago to come out to the Michigan Soldiers' Home and speak at the Memorial Day Exercises. When I saw him he was somewhat alarmed and I asked him what was the matter and he said, "Well, it is this invitation," and he let me read it. It said, "You are invited to be one of the speakers at our Memorial Day Exercises. The program will open with a talk by the Mayor and the recitation of Lincoln's Gettysburg Address by a veteran of the Spanish American War. Your talk and then the firing squad."

Then, too, I think that the surroundings this evening among friendly engineers and their charming wives are going to be more congenial to me than the audience that I am going to address on Thursday this week who are all certified public accountants. While I have nothing against certified public accountants, still their committee keeps telling me, "Don't forget, Roger, these fellows all work for the Internal Revenue Department," and I finally said to them, "Well, who doesn't nowadays?"

However, I want to apologize before going any further, for bringing up any thoughts of March 15th on an occasion as pleasant as this. One thing about the committee—when they decided to have an architect for a toastmaster they selected one who had all the latest engineering improvements. You will notice that I have been wired for sound. This thing that I am wearing is an earphone, or a hearing aid, as the man who sells it prefers to call it. I tell you that because while 99 per cent of them know it, every once in awhile someone says to me, "What are you wearing that thing in your ear for?" I suppose they think I have trouble with my arches. I always explain to them that long-distance asked me to hold the wire and I took her too literally.

However, an earphone has its advantages, has its advantages for me, and it certainly has its advantages for you, because I used to make longer speeches and now I find I make much shorter speeches now that I can actually hear what I am saying. Of course, the advantage to me is that when Mr. Stafford or someone else comes in and starts talking, if it gets too monotonous, I can always turn it off.

My first duty, and a very pleasant duty, is to introduce to you the very nice people at the speaker's table who will be even nicer in your opinion and rise rapidly when you learn that only two of them at most are going to make any speeches, because very few of you are equipped with anything that you can turn off.

Presentations

J. F. McIntire, Detroit, past president of the Society, was introduced and presented on behalf of the Society the President's Memory Book to Past President Blankin, who acknowledged it with a brief word of appreciation.

Prof. L. G. Miller, East Lansing, Mich., a member of the Council, was introduced, and on behalf of the Western Michigan Chapter, presented the Past President's Plaque to C. H. Pesterfield for his services to and leadership of the Chapter.

Toastmaster Allen explained confidentially that, "there isn't much difference between an architect and an engineer. An architect gets things wrong and an engineer gets things wrong too, but an engineer can do it faster because he uses a slide rule."

Some Fine Points on Geography

He then explained some of the fine points of salesmanship and introduced Prof. Edward C. Prophet, Associate Professor of Geography at Michigan State College, who has given 500 radio broadcasts and over 350 talks in the past two and one half years on the subject *Geography in the News*. With the aid of a series of maps the speaker explained that he hoped to give a somewhat different viewpoint on the war and present a means of interpreting the war news that is now being published. He explained that the present war activities are being covered so extensively that one of the greatest difficulties is to interpret the information. He also explained that this gives the greatest possible opportunity for propaganda.

He reviewed the invasion picture and called attention to the layout of ports on the Southern coast of England which he said, "told a greater story about where the invasion would occur than the French side of the map would reveal."

He described the area of the Cotentin Peninsula and the advantages of making a landing in that area. He pointed out that, while the establishment of the Normandy bridgehead was receiving most of the attention in the news, some very interesting developments were to be found on other fronts, particularly on the Karelia Peninsula. He also reviewed the situation in Italy and said "the attack was made at the wrong time of year in the Mediterranean area, as the summers are dry and the winter campaign had to be carried on in rain and the worst possible weather conditions." He then shifted to the situation inside China and pointed out that Japan's effort was directed toward the establishment of a strong north and south line to prevent us from getting our bases and supplies in the Eastern part.

Professor Prophet spoke of the war in the Pacific, and said that we were still dealing with the outposts of Japan and said that it must not be assumed that this war is anywhere near over.

In summing up he reminded the audience that we have a bridgehead on just a small part of France. The European situation may move more rapidly, but we still have many miles to go. It may be weeks and it may be several months before a major attack can start.

The Asiatic situation is not too favorable, and he said that everyone must do more in the way of war production than we have done before. He then mentioned some of the places where help was needed and said, it isn't the time to let down. Don't start counting the time until you get back to normal as there will be a new normal in the future. You

Mr. and Mrs. H. D. Bratt and T. D. Stafford prepare for Dutch party

will have to remain alert and fit yourself into it and not wait for things to come back to you.

Special Events

On Sunday afternoon some of the early arrivals enjoyed a tour of the City and also in the evening attended a buffet supper in the grille room of the Pantlind. On Monday evening there was a unique Dutch Treat Party, with all of the Committee members dressed in authentic Dutch costumes. A menu of typical Dutch food was served, and the diners greatly enjoyed the evening, having been instructed to ban the English words "yes" and "no" and the equivalents in Dutch were required. As a result of many infringements a fund of about $32.00 was collected for the Queen Wilhelmina Relief Fund. Dutch folk dances were performed by eight girls from Holland, Mich. Voluntary quartets chosen from the audience were presented and their efforts were transcribed for posterity.

Dutch songs and group singing were led by Mrs. Schuitema and Mrs. Buiten. The costumed hosts with their wooden shoes presented an original skit and H. D. Bratt acted as interpreter for the audience. These Western Michigan Dutchmen protested to their leader, who was the only one to understand and speak English, that they had great difficulty in understanding the Society's technical sessions when presented in English, and stated that it was now their purpose to organize a Dutch chapter of the Society.

M. F. Blankin, past president of the Society, was then called upon to explain the fundamental purposes and benefits of the membership. After the preliminary organization work had been completed, Pres. S. H. Downs, was invited to present a paper on Reynold's Numbers in Dutch, and he was required to don a Dutch costume before giving his paper.

On Monday afternoon 60 ladies made an inspection of the Grand Rapids Furniture Museum and Baker Furniture Company's showroom, where they viewed some rare antiques as well as contemporary period furniture. Some of the wood carvings of Anton Lang's collection were placed in view by the American Seating Co.

A luncheon-bridge was held at the Cascade Hills Country Club on Tuesday and 69 ladies attended.

What Makes an Engineer Tick*

By Dr. M. M. McGorrill, D.D.
Grand Rapids, Mich.

WHAT MAKES an Engineer Tick? was the question suggested by your Chairman, and I shall endeavor to give you the answer.

It is quite obvious that an engineer is only a man operating not under an assumed name but in a field that is quite well defined. Therefore if I move the implications of the topic over into the field of an engineer as a man, you will know that I am well within the area encompassed by the question which I have put to myself. It is quite obvious to you that, being a clergyman, I know absolutely nothing about the job which is yours, in any of its technical fields. If I should endeavor to speak upon any topic involving the particular professional skills that you have or ought to have, you would be justified in walking out—or at least going to sleep while I am talking. But I am talking to you about a problem which is, to my mind, the greatest single problem which faces the world at the present time.

Whatever your technical tasks may be, there is one thing that you do in company with all other persons. You are either heads of businesses or executives. Certainly you are in prominent places in the particular lines of work in which you are engaged. You therefore are in places of leadership. What I have to say involves a conception of yourselves as leaders.

The greatest problem that you face is the problem of getting along with people. There is no other single thing that is so worrying the world as that one, right now.

The war is a product of the fact that we did not know how to get along, or that others did not want to get along.

This morning I was asked by a man to allow the suggestion of my name as an arbiter in a wage dispute. What is that? That is a problem in human relations—partly a matter of money, undoubtedly; but basically, fundamentally, it is a problem of how to get along with people.

We have racial problems and nationality problems and class problems, and problems that will try and test and worry the minds of persons everywhere for decades and decades to come. The thing is never-ending.

You may break down your job into four classifications: specifications, materials, the laws that you have to know about and utilize and the purposes of the plant or structure. Those four things are fundamental. You have to be sure, however, that the *doctrine* which you use representing the laws—not the man-made laws, but the natural laws—is sound and accurate. If you are caught misusing the laws you pay a very heavy price, because the very structure that you build, whatever it may be, whatever materials you may utilize, must conform to the laws governing those materials, or there is trouble ahead for you and for the organization that you represent.

The clergyman calls it doctrine; the scientist calls it laws; whatever it is, it is all made up of the same thing, namely, you had better get your intellectual formulations straight. You had better know what the forces are that you are dealing with. Otherwise you will come to grief not only as persons but also as engineers.

I am briefly trying to say to you in what I call the Ten Commandments the things that underlie human relationships. Whether it be in the conduct of your business or in the judgment that you exercise in the political realm, or even getting along with your wives—whatever be the area in which you try to apply it, you must have your doctrine straight. You need to see and know and feel and understand the forces that you do not completely comprehend in nature but whose powers you may channel into constructive service.

The first thing, then, is: *discriminate between the materials that you deal with.* You are dealing with physical things and dealing with natural laws, but you are dealing also as heads of businesses and executives with people. The pipe that was placed in a building last night is the same thing this morning. It has not changed its consistency, except atmospheric influence, unless someone has tampered with it. But the man you left last night may be a wholly different person this morning. If you, as an engineer on physical things, forget yourself as a dealer in human relations, your material things may have to go by the board for a while, as you deal with the person, who is primarily not a material thing at all. He has hopes, he has ambitions, he has sorrows, he has problems, he has anxieties, he can be hurt. The pipe cannot be hurt—but a man can be. A pipe has no desire to be anything other than what it is. It does not have any consciousness of self. But a man does, and he it is that you must deal with in directing the forces which make him what he is.

We have just come in the past 15 or 20 years to understand that. To deal with the people whom we have to direct is just as important as dealing with the materials those people use. You have to discriminate between the materials that you use, the hard stuff that you work with, and the men under whom and with whom you do your work.

The second thing: when you deal with them you have to

*Address delivered at Get-Together Luncheon in Grille Room, Pantlind Hotel, during ASHVE Semi-Annual Meeting, Grand Rapids, Mich., June 19-20, 1944.

help them to realize the potentialities within them. There are certain forces within people, certain great forces. They may be redirected. They may be stunted or they may be developed or they may be utterly crushed. You leaders have one supreme task—to get your job done, yes; but in getting that job done to help men realize the possibilities that lie within themselves.

Ernest De Witt Burton for two years was President of the University of Chicago. The greatest thing ever said about him was said, I think, at his funeral, in one sentence. If any of you happened to know Burton, you know that he was a white-haired, austere-looking man, one with whom we would consider it perhaps unpleasant to have much in the way of personal relations. But the man who knew him best said, "Every man was at his best in Burton's presence." What a tribute! The executive of a great university! Of how many men who are executives can that be truly said?

It is a great thing when you lead an organization—when men have to work under you and take orders from you, when you are the boss, to stand before them or sit with them in your presence and so conduct yourself that each man who takes orders from you can say, "I am at my best in that man's presence."

That is leadership. That comes close to the Christian gospel.

Whenever I hear a certain spiritual sung over the radio by a Negro choir—I recognize that the theologians and the philosophers have not come within a long sea mile of the intuitive accuracy that the Negro attained when he put into words the feeling of his own heart—"All God's Chillun Got Wings."

If you know anything about the Bible you will know that the word "wings" as a symbol, stands for divinity. Whenever wings are present, it means the presense of divinity. The Negro moved intuitively to say of us all the principle that we shall have to utilize when the war is over in dealing with peoples all around the earth. We may damn their ideologies; we may decry their systems; we may stamp out their regimented education; we may set loose in them certain processes that mean at least freedom. But all these will be predicated upon our faith, if we have it, that "all God's chillun got wings."

People are precious. They have possibilities within them. You are a leader; you are an executive, so called. Help men to realize the possibilities within them.

Third, *enable men to see their mistakes, not in the sense that they are not as able as they thought themselves to be—but rather that they have in them more than as yet has been revealed.*

The personnel director of a corporation here in town whom I know very well was talking to me about what he does with a workman who has made a mistake. He takes that workman and, instead of damning him to high heaven or to lowest hell, he cashes in on the humiliation and shame of a workman who has made a stupid mistake. Instead of throwing him out the director lets it be known that perhaps this is the most constructive thing a man could utilize to make him aware of what his job is.

A very astute football coach took his men one day into the locker room. It was between the halves, and one of the best players had made a blunder so tremendous that the fans were calling for him to be taken out of the game. The coach talked to the men. He never said a word to this fellow. The time was passing rapidly, and the player was waiting for the "bawling-out" that he was to have but not a word. Then the coach, with a tremendous call to go out and fight, let them go. Turning to the offending player, he said "You stay." And then he said something like this: "I know how you feel. Nothing that I can say would make you feel any worse. You have said it all to yourself. Now, Bill, go on out there. Do the thing that is in you!" And that football player went out and played as never before. That coach knew human nature.

Enable men to see their mistakes not in terms of their not being as capable as they think they are, but in terms of their having in them more than they have as yet revealed.

Next, *assume good will on the part of the other man.* Do you think this will always work for you? No, it will not work always. But it is amazing how many times it will work. There are so many of us who go around making decisions for other people. We want them to do something but we say, "Jack will never do that! Why bother even to ask him?" Why not let Jack make the decision? Why not assume good will on the part of the other fellow and let him take the first step in refusing to cooperate?

I learned that one night during the course of a very important incident. In my job as a clergyman I have had to raise much money for churches. I went out one night when I had to raise $5,000 for the institution of which I was then the minister, and Mount Everest never looked any higher to anyone than did that $5,000 to me. We needed it for a special purpose.

I went to see a man who lived in a beautiful house. He ushered me into his living room and we visited for about half an hour before I could get up sufficient courage to say what I wanted. Then I told him what I came for, and I wondered whether I should ask him for $200 for the institution. As I talked I made up my mind that I would not name a sum. I thought I would leave it to him. So I said, "Mr. So-and-so, you know whether you want to give to this particular fund. You know also how much you want to give. It would be presumptuous on my part to tell you." I had just reached that decision.

He said—he was very suave and very pleasant and always dignified—with a little bow, "Mr. McGorrill, I realize what you have told me. I appreciate the way in which you have done it. I shall not forget it. You may expect something from me. It will not take your breath away, but I shall be glad to do something."

So I thought, "Well, I've done it now! I should have set an amount." Then I went out.

In a few days I received a check for $500. If I had asked him for $200, he would have given me $200, but it would have cost the institution $300 for me to obtain the $200. But by a simple principle, that of assuming good will on the other fellow's part, I decided to let him make the decision—and thank goodness that I did, because he gave $500 a year for years afterwards to that institution.

When you deal with people, assume their good will. You will not always win. Sometimes you will be hit in the face. But it is just amazing how much farther leadership gets when people assume good will and let the other fellow take the first step in failure to cooperate.

Next, *be sure that a clear understanding exists between you and your men, as to what is required in the job.* People do not like to display their ignorance in front of you. Your subordinates assume a knowledge that they ofttimes do not possess. Be sure that you have made clear to them what ought to be known, so that they may have a comprehension of it. Yours is the task to do it.

Give your workers an understanding of the relationship of the job they are doing to the total task. The man who first told the story of interviews with three laborers set forth a profound truth. He was walking along the street and here were three men laying bricks.

He said to the first man, "What are you doing?"

The man said, "I am working for eight dollars a day." (That was when eight dollars a day meant something to them.)

The second man to whom he put the question replied, "I am laying brick."

And the third man said "I am building a cathedral."

All of them were laying brick and all of them were earning eight dollars a day. But I would bet my last year's hat on the third man. He had a comprehension of what his job meant.

One day a very competent and highgrade industrial executive was going through his plant. He passed a certain bench and he heard two men talking. One of them said to the other "Who are those two fellows in front?"

The other fellow said using an unspeakable name "They are so-and-sos. They ride around in Pullman cars, stay at the best hotels and smoke 25-cent cigars while we support them."

The executive heard that. He walked around the room

and came back. He said to the men, "I happen to have overheard what you said about those two salesmen at the front of the room. I wonder, men, if you understand what they do? They have to be very good salesmen for our prices are higher than our competitors' prices, for the reason that we pay you more than our competitors pay their workers. If our goods back up there in the warehouse, we could stand it for a week. We might stand it for two weeks or three, but surely not longer than a month. These men have to win, and instead of your supporting them, they are helping to support you."

Then the executive said to me, "That incident made me make a change in business policy. I instituted a program of inter-departmental understanding of what relationships were."

That is leadership. One of the crying difficulties of modern industrialism lies right there—that millions of men do not know the meaning or the purpose they serve in the various organizations of which they are a part. We are de-personalizing people.

"Ill fares the land, to hastening ills a prey
Where wealth accumulates, and men decay."

Next, *protect a person's self-respect.* You can lose more real leadership at that point than at almost any other that I know. If you must discipline people, discipline them singly. Do not make a man feel inferior in the presence of his peers. Did you ever try that with a child? If you have two or three children in your home and you discipline one in front of another, you have created for a time an enemy, because that child has been made to feel inferior in the sight of his brothers and sisters. That destroys something in him. Men, too, feel that way.

I learned that as a result of one of the most stupid things I ever did. A trustee of an organization came into the trustees' meeting one night and let off a blast about the conduct of the board. He said that he had never seen a statement of the finances of the institution. I picked him right up and said, "Did you receive a letter from the church today?"

He said, "Yes."

I said, "Did you read it?"

"He said, "Yes."

"Well," I said, "in that letter was a complete statement up to the day before yesterday of the obligations of the church, the accounts payable and so on. Why do you come in here and say that you never saw a statement before?"

He never said a word. I had blown off. I had shown him my authority. He had the very information that he wanted, right in his pocket, and he was too mean to admit it. That is what I thought. But that cost me something serious. That fellow never came to church again except when I was not preaching. Never did he speak to me again. That man died without my ever apologizing to him, because I was too sure of my own infallibility. He died, and I have been hurt ever since, that he, an honest farmer, was humiliated by me in front of his peers. I was a low-down fool.

Many a man has made that mistake. You deal with other people and you need to protect their self-respect.

Next, *keep yourself under control.* I will pass that one over with the sentence that no man can lead others who has not first mastered himself.

And then to the tenth one: Realize, you engineers—you are men first, and you are citizens of a democracy—that the way you conduct yourselves, the way you conduct your businesses, the way you lead others, has a definite part in the perpetuation of democracy. If you regard yourself as top sergeants, that attitude is totalitarian. The way you act as leaders has as much to do with the perpetuation of democracy as anything that the government in Washington does or does not do.

Democracy will live or die in terms of what you and I, its citizens, do in frankly and honestly trying to practice the principles of respect for personality, of utilization of the spiritual forces—for democracy deals with the spirit.

Tyranny controls men's bodies and stifles the spirit.

Three mornings a week I speak over the radio on a program called "Faith for America." Whenever I touch upon the personal applications of the great spiritual and moral values which are our heritage in America, a heritage that we want to give to the entire world, our own system they may take or not take. Whenever I talk upon these things in personal terms I have telephone calls and letters requesting copies of my talk.

We need to rediscover the Faith for America—that faith that applies to you and me personally, individually—for the way that we act, more than anything else, will perpetuate democracy, will extend the blessings of liberty, and will afford a chance for justice in a world that has lost its way.

Robinson said, "There is no star in all the shrouded heavens anywhere," "but a star is there. It is ours to use. By its light we may live."

Engineers are men; they are leaders. The forces they utilize are basically the spiritual and moral ones.

The best to you! Success to you! As you solve not only complicated engineering problems, but make your contributions to the problems of human relationships which can make or break not only this nation but the world, blessings on you.

COUNCIL MEETING

A regular meeting of the Council was held June 18, and 16 of the 18 members were present when Pres. S. H. Downs called the meeting to order. Reports from the Executive, Finance, Membership, Meetings, and Standards Committees were received.

The Executive Committee recommended places for future meetings of the Society; the Finance Committee presented a series of charted studies of the Society's financial transactions and membership growth from 1922 to 1943; the Membership Committee reported receipt of 384 applications during the first six months of the year; the Meetings Committee recommended a special study be made by the Constitution and By Laws Committee to clearly define the scope and duties of that Committee and the Meetings Committee; and the Standards Committee submitted a report on the history of codes developed by the Society since 1920.

Prof. G. L. Tuve, chairman of the Committee on Research, outlined 30 projects which are under consideration.

The War Service Committee reported on matters referred to it, and Prof. C.-E. A. Winslow, chairman of the F. Paul Anderson Award Committee, gave a report on the status of the fund and said no nominations had been received. It was decided that no award for the F. Paul Anderson Medal would be made this year.

J. F. Collins, Jr., chairman of the Guide Publication Committee, gave the latest developments on the publication of the 1945 edition.

A charter was granted to Memphis, Tenn., members for a local chapter of the Society, and a new contract for the publication of the ASHVE Journal Section, in Heating, Piping and Air Conditioning, was approved.

The nomination of five members to serve on the Committee on Research for three-year term, commencing in January, 1945, was made.

VICE-PRESIDENTS TO VISIT CHAPTERS

First Vice-President C.-E. A. Winslow, New Haven, Conn., professor of Public Health, Yale University, is scheduled to visit the following local chapters during September: Greensboro, N. C.; Atlanta, Ga.; New Orleans, La.; Houston, and Dallas, Tex.; Oklahoma City, and Kansas City, Mo. His subjects will be *The Engineer in Post War World*, and the *Air Cooled Human Body.*

Second Vice-President A. J. Offner, New York, consulting engineer, will speak at the October meetings of the Iowa and Nebraska Chapters, on the subject of, *Air Conditioning and Heating in Latin American Countries.*

Train Piston Action Ventilation and Atmospheric Conditions in Chicago Subways

By Walter E. Rasmus* and Edison Brock**

THIS is the report of a survey of air movements resulting from train operation, and of atmospheric conditions in the State Street route of the Chicago subways, which was opened to the public in October, 1943.† The effectiveness of the piston action of trains in providing large volumes of tunnel ventilation has long been recognized. As early as 1910 air flow measurements resulting from the joint action of trains and exhaust fans were made in the tubes of the Hudson and Manhattan Railroad Co. and reported in connection with an investigation of ventilation.[1]

Introduction

In 1938 when construction was started on the Chicago subways a review of available technical literature disclosed frequent general references to the subject but meager specific data and no comprehensive theoretical analysis. It was realized that the anticipated heavy traffic operating in single track tubes would cause severe piston effect upon the air and also give out great quantities of heat which would have to be disposed of. In order to coordinate available data so that it might be applicable to the Chicago subways and to establish standards for design of ventilation facilities, a method for calculating the effect of train piston action on the subway air was originated and this theoretical analysis was extended to include a heat balance.[2]

It was not until much of the work on the Chicago tubes was completed that the account of a ventilation survey relative to the problem of smoke removal in the Moffat Tunnel was released. In that report the analysis of train piston effect and accompanying formulae and air flow diagrams are supported by field measurements with both train and fan operation.[3]

It is acknowledged that no exact theoretical solution of air flow is possible in the case of the typical rapid transit subway with its numerous station entrances, vent shafts, open platforms and with trains varying in frequency, speed and direction of travel. For the same reasons it is equally true that no fully accurate determination of air flow by field measurements is possible. However, a theoretical analysis is of value in establishing design requirements and an operating survey should follow to determine if these objectives have been attained.

The survey described herein does not pretend to have laboratory exactness but it has been conducted as carefully as practical considerations permitted, and it is believed that the resultant data are amply accurate for the purposes intended.

Description of Chicago Subways

The design of the Chicago subways with respect to ventilation has been previously described and illustrated,[4] and an engineering summary of the work will be available to the reader.[5] The following description is therefore limited to the survey of train piston action ventilation and atmospheric conditions.

Fig. 1, showing a general plan of initial system of subways for Chicago, includes both State Street and Dearborn Street routes. The former, which was placed in service in October 1943, is connected at both portals by inclined tracks to the elevated lines of the Chicago Rapid Transit Co. and certain express services are now routed through the subway. Heavy construction work for the Dearborn Street subway has been completed for the greater portion of its length, but installation of station finish and equipment has been temporarily deferred because of the war. Both routes have two deep level tubes, each with a single track, and these subways are independent except for block-long pedestrian passageway connections, four in number, in the downtown area. While the construction and ventilation provisions are similar, the following description is confined to State Street subway.

North of the Chicago River the stations at Grand Avenue, Chicago Avenue and North Avenue are of the side platform type with the central wall of the tubes continued between tracks. The Clark Street station, and all stations south of the Chicago River, have open central platforms serving both tracks. All platforms are 500 ft long except that one platform 22 ft wide and 3,400 ft long serves the eight downtown stations. There are usually four sidewalk entrances and stairways between the street surface and each mezzanine station and two combinations of an escalator and a stairway connecting the mezzanine with the platform level. The essential dimensions of the State Street subway are shown in Table 1. Typ-

*Engineer of Subway Design, City of Chicago, Department of Subways and Superhighways.

**Mechanical Engineer, Federal Works Agency, Chicago Subway Project.

†Investigation conducted by the engineers of the Department of Subways and Superhighways, the Federal Works Agency and the Chicago Rapid Transit Co.

[1]Ventilation of the Hudson River Tubes, by A. W. Hodgson. (*Heating and Ventilating*, Vol. VII, No. 5, May 1910.)

Presented at the Semi-Annual Meeting of the American Society of Heating and Ventilating Engineers, Grand Rapids, Mich., June 1944.

[2]Development of Formulae for Calculating Ventilation for the Chicago Subways, by Edison Brock. (*Journal of the Western Society of Engineers*, Vol. 48, No. 2, June 1943.)

[3]Piston Effect of Trains in Tunnels, by R. L. Daugherty. (*ASME Transactions*, Vol. 64, No. 2, February 1942.)

[4]Ventilation of the New Chicago Subway, by Walter E. Rasmus. (*Heating, Piping & Air Conditioning*, Vol. 15, No. 8, August 1943.)

[5]Construction of Chicago's First Subways. (A series of papers by 17 Engineers, presented in abstract January 6, 1944, to be published in the *Journal of the Western Society of Engineers*, Vol. 49, No. 2, Part 2, June 1944.)

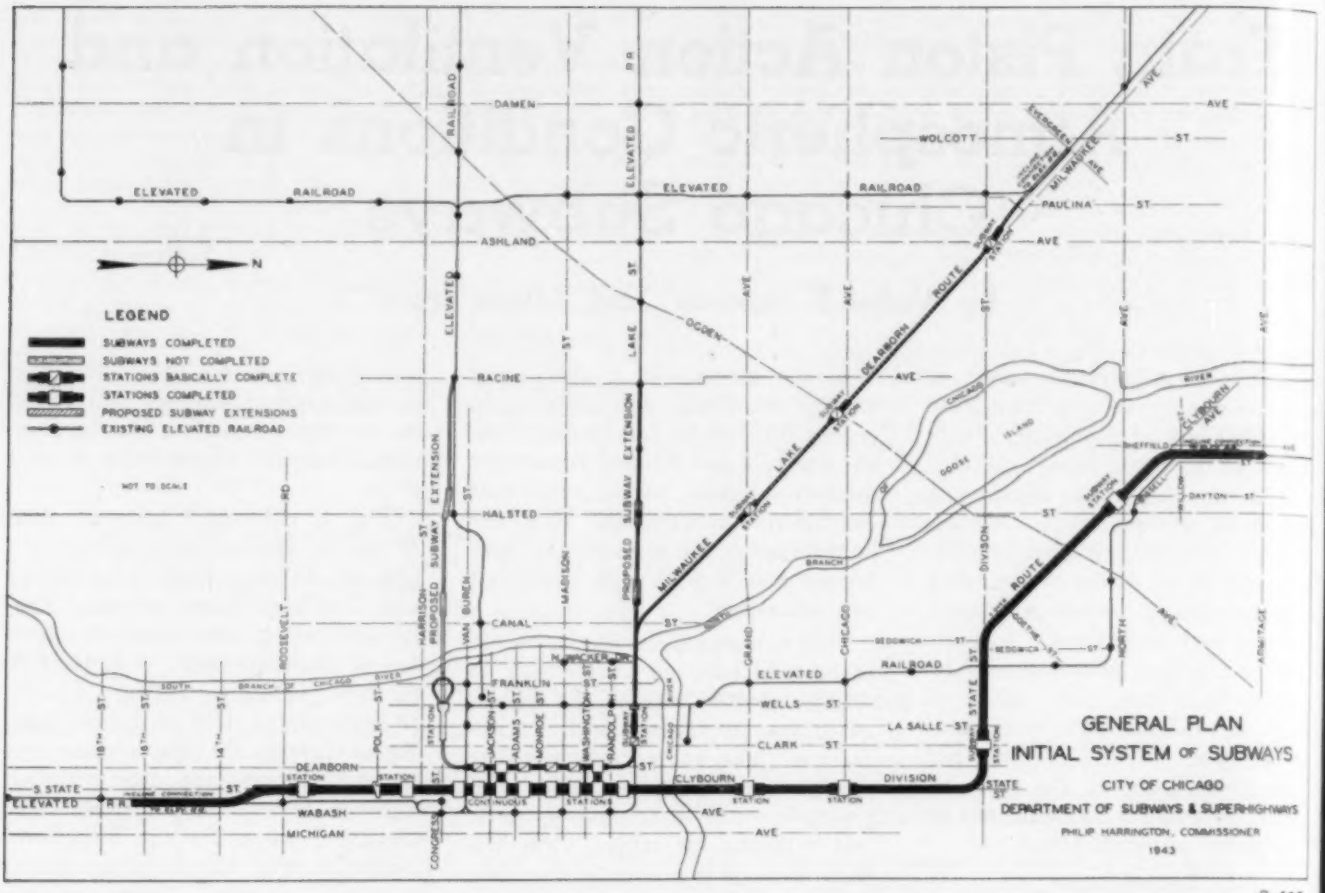

Fig. 1—General plan, initial system of subways

ical sections of State Street subway are shown in Fig. 2.

Test Procedure

In order to observe the piston action of trains upon the subway air under as nearly uniform conditions as possible, all air flow measurements were made during the off-peak period between 9:00 a.m. and 3:00 p.m. The average train consisted of four 50-ft all steel cars running on a three minute headway with approximately 40 trains per hour on the two tracks. Maximum train speeds were 29 mph to 38 mph, depending upon distance between station stops. During morning and evening rush hours, train lengths are increased to eight cars, but this is offset by lighter traffic after midnight, so that the observations represent a fair average under present traffic conditions.

Air velocities were measured with an Alnor Boyle type of velometer having two scales giving instantaneous indications to a maximum of 500 fpm and 2,500 fpm, respectively. On account of fluctuations in velocity and frequent reversals in direction of air flow this type of instrument proved more suitable than an anemometer.

During each observation air velocity indications were recorded on a log sheet at 5-second intervals for a period of not less than 10 min. In order to secure a fair average, at least three observations were made at each location, preferably on different days. Such procedure was necessary because variation in train headway cannot be avoided and this, together with frequent station stops and the combinations of effects of trains operating on adjacent tracks, causes an irregular pumping action with peak velocities normally outward and then inward as each train passes. As the present survey under one set of conditions requires approximately 50,000 instantaneous meter readings, the average results should establish the characteristic subway air movement with reasonable accuracy.

Table 1—State Street Subway Dimensions

Type	Length (ft)	Area (sq ft)	Perimeter (ft)	Volume (cu ft)
Portals:				
South	568	225	60	127,800
North	700	266	67	186,200
Horse-shoe Section	24,271	235	64	5,703,685
Circular Shield Section	4,214	290	70	1,222,060
Crossovers:				
Roosevelt Road	450	687	119	309,150
Illinois Street	177.5	509	93	90,348
Clybourn Avenue	177.5	509	93	90,348
Station Sections (Side Platform Type):				
North Avenue	1,000	340	163	340,000
Chicago Avenue	1,000	340	163	340,000
Grand Avenue	1,000	340	163	340,000
Station Sections (Center Platform Type):				
Clark Street	506	721	130	364,826
Downtown	3,413	623	139	2,126,299
Harrison Street	625	623	139	389,375
Roosevelt Road	683	622	151	424,826
			Total	12,054,917

Since the two train tubes are interconnected and the air circulates rapidly along the tracks between the subway sections, it was necessary to measure velocities in all structures and pedestrian passageways connecting the tubes to the outer atmosphere. The air flow into the downtown section by way of the tunnels was also measured to permit a summation of air movement in this section. The number and approximate area of openings from train tube level to the street surface are as follows:

	Locations	Sq Ft
4	Train tube entrance at subway portals	982
32	Escalator and stairwells from train platforms to mezzanine stations	2,320
36	Standard blast shafts in tubes adjacent to stations	3,600
44	Standard vent shafts with louvers between stations	4,400
13	Downtown station vents with fans	482
Total 129	Approximate area	11,784

The standard vent and blast shafts, which are similar in design, provide ventilation and balance air pressures, the latter located immediately in advance of and beyond station platforms to limit air velocities at these locations. Each vent or blast shaft unit is composed of two to four cylindrical vertical wells with a combined area of 100 sq ft, with connections at the base through the tube wall. Each terminates in 120 sq ft of sidewalk grating. As the survey reported herein was conducted in winter, the vent shaft louvers were closed to retain heat but the blast shafts were open. There are 26 fans with a combined capacity of 1,124,000 cfm for supplementary ventilation and emergency use. To obtain an accurate record of train piston action alone, none of the fans was operated during the test period. The fans are the axial flow type without housings. They are mounted in the air vents for economy and space saving, and the fan discharge ducts serve also for the passage of piston action air flow. The arrangement of fans and various structures for ventilation has been described and illustrated.[6, 7] The air flows measured were due to train operation, natural influences being negligible. Ventilation can be increased at will by opening vent louvers and by operating the fans.

Inasmuch as one of the main functions of subway ventilation is the disposal of heat generated by car motors and other equipment, a continuous record has been kept of subway temperatures by means of 12 recording thermometers installed at representative locations. They are of the self contained type with 7-day manually wound clock movements, 0 F to 100 F scale, and are guaranteed to be accurate within one deg above or below the exact air temperature.

In addition to the general survey, a number of specific investigations were conducted, several of which are described in this paper.

Results of Air Flow Tests in Downtown Station Area

While the survey for the State Street subway has progressed sufficiently to warrant a general discussion of the characteristic air flow and atmospheric conditions for the entire subway, further meter readings will be required at certain locations to confirm the present data. However, three or more sets of observations have been made throughout the downtown section from Lake Street to Congress Street. The results are shown in Table 2 and Fig. 4.

The location of this area is indicated in Fig. 1 and a typical cross section is shown in Fig. 3. It will be noted that the parallel tubes, serving the northbound and southbound tracks, open to a central platform 22 ft wide and 3,400 ft long. This platform serves eight mezzanine passenger stations, each of which has four stair entrances in the sidewalk and two sets of a stairway and an escalator in combination connecting with the train platform, except that the Van Buren-Congress station, the southernmost of this group of stations, has but one such joint escalator and stairway. Beyond the ends of this continuous platform, the train tubes are separated, each with its single track.

Table 2 gives a summary of air movement in and out of the platform level of this section at all possible locations; that is, at the four train tube connections of which there are two at each platform end, at the 15 escalator and stairway combinations, and at the 13 fan ducts. In each downtown station, these fan ducts terminate adjacent to the southwest and northeast stair entrances. Since they serve as air vents irrespective of fan operation, they are designated as S.W. and N.E. air vents. The summation of air flow indicates 403,395 cfm supply and 413,229 cfm exhaust for this section of subway. The mean, 408,312 cfm, is considered as representing this section's characteristic air flow. This is sufficient to change the 2,126,300 cu ft volume of the section 11 times per hour. Since the fans were not being operated when this survey was made, and natural effects were found to be minor, this movement of air may be assumed to represent the average ventilation due to the piston action of the trains.

It is evident that all of this air supply does not come directly from

[6] Loc. Cit., see Note 4.
[7] Loc. Cit., see Note 5.

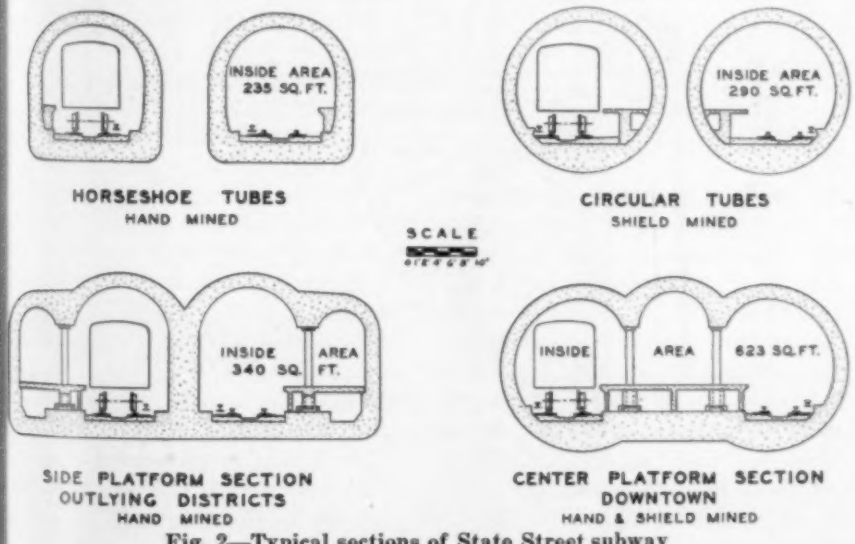

Fig. 2—Typical sections of State Street subway

Table 2—Tabulation of Test Results of Downtown Section of State Street Subway

No. of Readings	Location of Observations	Velocity of Air Flow fpm Max. Out	Max. In	Ave. Out	Ave. In	Duration of Air Flow Per Cent Out	In	None	Air Flow cfm Out	In
360	Lake-Randolph, N. Stair	900	400	233	140	64.2	30.3	5.5	12,865	3,659
360	Lake-Randolph, S. Stair	525	350	202	105	61.0	33.3	5.7	10,588	3,008
360	Randolph-Washington, N. Stair	700	470	256	201	72.5	20.3	7.2	15,916	3,494
360	Randolph-Washington, S. Stair	900	500	279	248	53.9	37.5	8.6	12,982	7,970
360	Washington-Madison, N. Stair	800	600	323	193	76.1	15.8	8.1	21,130	2,614
360	Washington-Madison, S. Stair	700	550	240	264	43.2	48.3	8.5	8,889	11,048
360	Madison-Monroe, N. Stair	700	500	368	248	76.3	18.3	5.4	24,173	3,909
360	Madison-Monroe, S. Stair	900	400	270	148	69.4	24.2	6.4	16,159	3,084
360	Monroe-Adams, N. Stair	800	350	240	76	80.0	18.7	1.3	16,548	1,535
360	Monroe-Adams, S. Stair	950	550	274	168	78.0	17.9	4.1	18,389	2,581
360	Adams-Jackson, N. Stair	850	550	282	232	62.8	33.9	3.3	15,192	6,720
360	Adams-Jackson, S. Stair	850	400	316	186	81.7	12.5	5.8	22,152	1,984
360	Jackson-Van Buren, N. Stair	750	500	252	200	70.6	24.4	5.0	15,298	4,230
360	Jackson-Van Buren, S. Stair	1,000	450	303	145	75.9	19.1	5.0	19,769	2,391
360	Van Buren-Congress, Stair	600	650	252	309	20.6	69.8	9.6	4,467	18,461
5,400	Total air flow via 15 combined stair and escalator wells								234,517	76,388
4,680	Total air flow via 13 air vents (Station fan discharge ducts)								24,882	12,032
720	Total air flow via tubes at north end—North Bound Tube								69,215	3,545
	South Bound Tube								1,150	155,211
720	Total air flow via tubes at south end—North Bound Tube								77	152,598
	South Bound Tube								83,388	3,615
11,520	Total air flow in downtown station area								413,229	403,385

out of doors but its volume is many times that normally supplied for breathing purposes, and it is comparatively fresh, much of it having entered the subway at nearby blast shafts in the train tubes.

Such a large volume of piston action air movement had not been anticipated. The survey also revealed a pronounced characteristic air flow of even greater value in obtaining and maintaining excellent atmospheric conditions in these heavily patronized downtown stations. It will be noted that the predominant combined air flow is inward at the two train tube connections at each end of the continuous platform and outward at seven of the eight passenger stations. The only exception is at the least important southernmost Van Buren-Congress Station through which the predominant air flow is inward, being similar to that through the adjacent tubes. As a result of this characteristic air movement, tempered air averaging 40 F even in the coldest weather, enters at the train tube connections and by mixture and heat from walls, trains and other sources, quickly rises to an even temperature of about 50 F. This temperature generally prevails at track level and in the important mezzanine stations as well as in the stairways to the street surface.

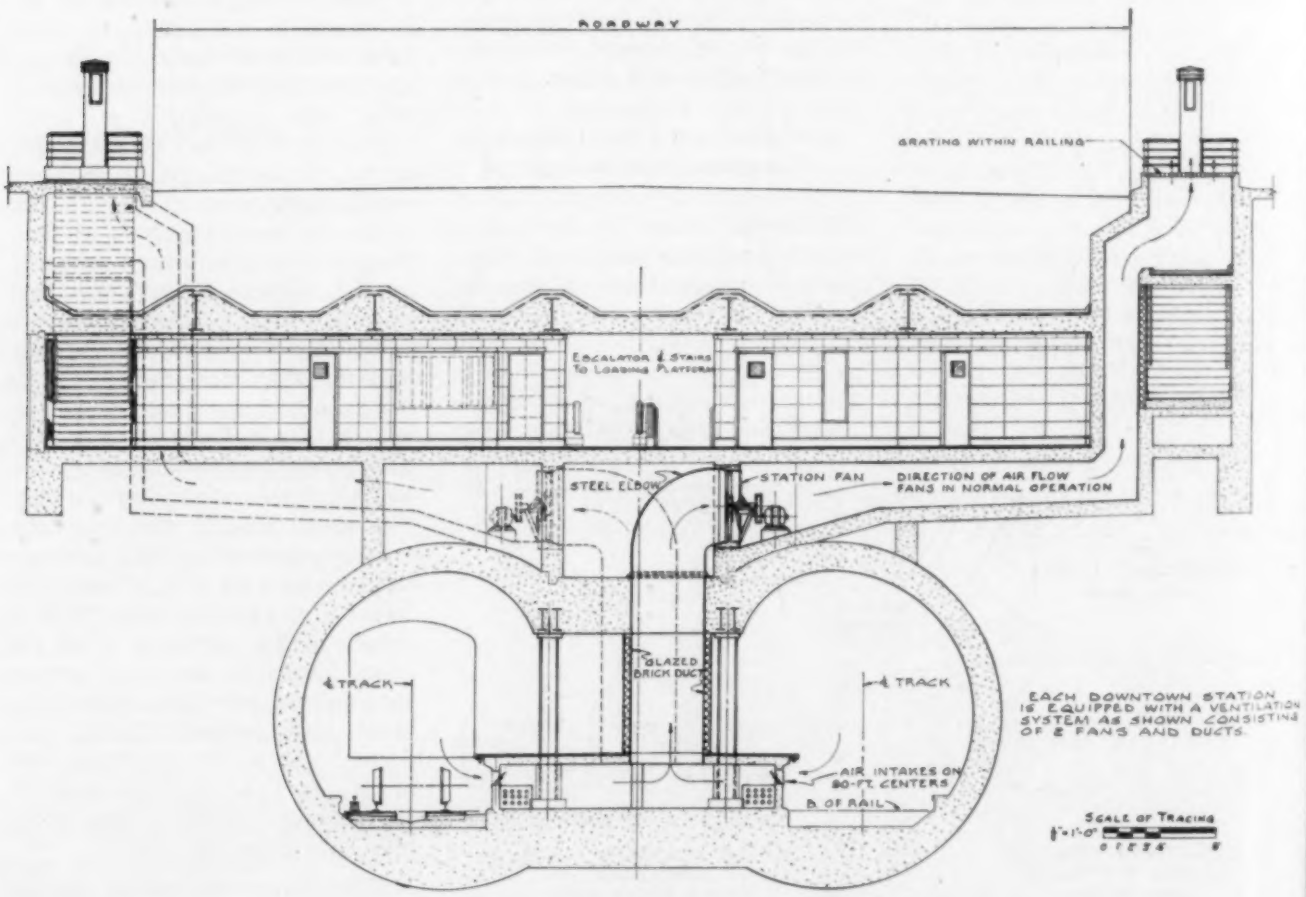
ROADWAY
GRATING WITHIN RAILING
ESCALATOR & STAIRS TO LOADING PLATFORM
STEEL ELBOW
STATION FAN
DIRECTION OF AIR FLOW FANS IN NORMAL OPERATION
GLAZED BRICK DUCT
℄ TRACK
℄ TRACK
AIR INTAKES ON 80-FT. CENTERS
TOP OF RAIL
EACH DOWNTOWN STATION IS EQUIPPED WITH A VENTILATION SYSTEM AS SHOWN CONSISTING OF 8 FANS AND DUCTS.
SCALE OF TRACING

Fig. 3—Typical ventilation system for downtown stations

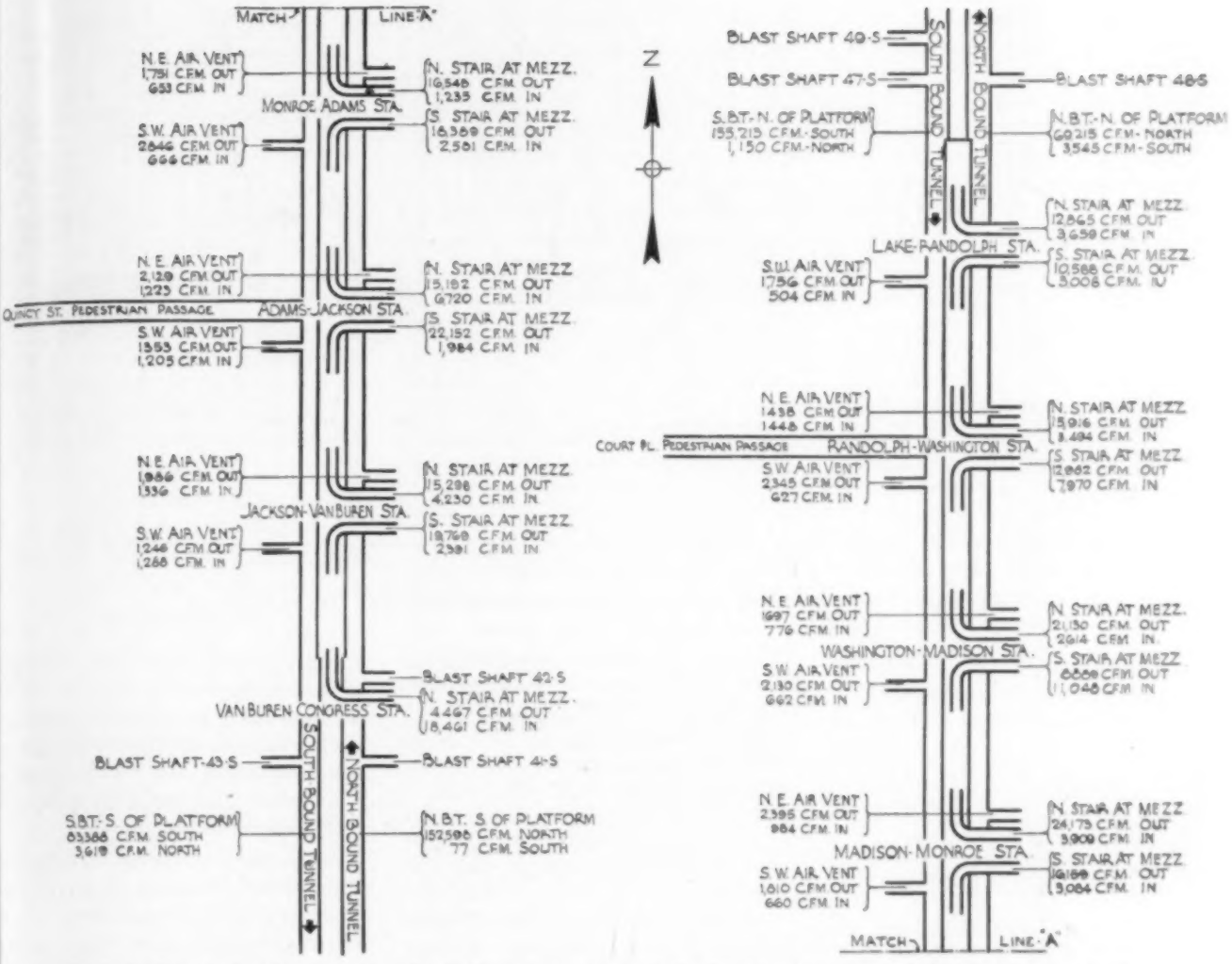
MATCH LINE 'A'
N.E. AIR VENT 1,791 C.F.M. OUT 653 C.F.M. IN
N. STAIR AT MEZZ. 16,548 C.F.M. OUT 1,235 C.F.M. IN
MONROE ADAMS STA.
S.W. AIR VENT 2846 C.F.M. OUT 666 C.F.M. IN
S. STAIR AT MEZZ. 16,369 C.F.M. OUT 2,581 C.F.M. IN
N.E. AIR VENT 2,129 C.F.M. OUT 1223 C.F.M. IN
N. STAIR AT MEZZ. 15,182 C.F.M. OUT 6720 C.F.M. IN
QUINCY ST. PEDESTRIAN PASSAGE
ADAMS-JACKSON STA.
S.W. AIR VENT 1353 C.F.M. OUT 1,205 C.F.M. IN
S. STAIR AT MEZZ. 22,152 C.F.M. OUT 1,984 C.F.M. IN
N.E. AIR VENT 1,986 C.F.M. OUT 1336 C.F.M. IN
N. STAIR AT MEZZ. 15,298 C.F.M. OUT 4,230 C.F.M. IN
JACKSON-VAN BUREN STA.
S.W. AIR VENT 1248 C.F.M. OUT 1,268 C.F.M. IN
S. STAIR AT MEZZ. 18,768 C.F.M. OUT 2391 C.F.M. IN
BLAST SHAFT 42-S
N. STAIR AT MEZZ. 4467 C.F.M. OUT 18,491 C.F.M. IN
VAN BUREN CONGRESS STA.
SOUTH BOUND TUNNEL
NORTH BOUND TUNNEL
BLAST SHAFT 43-S
BLAST SHAFT 41-S
S.B.T.-S. OF PLATFORM 63366 C.F.M. SOUTH 3,619 C.F.M. NORTH
N.B.T.-S. OF PLATFORM 152,598 C.F.M. NORTH 77 C.F.M. SOUTH
N
BLAST SHAFT 49-S
BLAST SHAFT 47-S
SOUTH BOUND TUNNEL
NORTH BOUND TUNNEL
BLAST SHAFT 48-S
S.B.T.-N. OF PLATFORM 155,219 C.F.M.-SOUTH 1,150 C.F.M.-NORTH
N.B.T.-N. OF PLATFORM 69,215 C.F.M.-NORTH 3,545 C.F.M.-SOUTH
N. STAIR AT MEZZ. 12,865 C.F.M. OUT 3,659 C.F.M. IN
LAKE-RANDOLPH STA.
S.W. AIR VENT 1756 C.F.M. OUT 504 C.F.M. IN
S. STAIR AT MEZZ. 10,588 C.F.M. OUT 3,008 C.F.M. IN
N.E. AIR VENT 1438 C.F.M. OUT 1448 C.F.M. IN
N. STAIR AT MEZZ. 15,916 C.F.M. OUT 3,494 C.F.M. IN
COURT PL. PEDESTRIAN PASSAGE
RANDOLPH-WASHINGTON STA.
S.W. AIR VENT 2345 C.F.M. OUT 627 C.F.M. IN
S. STAIR AT MEZZ. 12,662 C.F.M. OUT 7,970 C.F.M. IN
N.E. AIR VENT 1697 C.F.M. OUT 776 C.F.M. IN
N. STAIR AT MEZZ. 21,130 C.F.M. OUT 2614 C.F.M. IN
WASHINGTON-MADISON STA.
S.W. AIR VENT 2130 C.F.M. OUT 662 C.F.M. IN
S. STAIR AT MEZZ. 6666 C.F.M. OUT 11,048 C.F.M. IN
N.E. AIR VENT 2395 C.F.M. OUT 984 C.F.M. IN
N. STAIR AT MEZZ. 24,173 C.F.M. OUT 3,909 C.F.M. IN
MADISON-MONROE STA.
S.W. AIR VENT 1,610 C.F.M. OUT 660 C.F.M. IN
S. STAIR AT MEZZ. 16,188 C.F.M. OUT 3,084 C.F.M. IN
MATCH LINE 'A'

Fig. 4—Chart showing results of air flow measurements in downtown section of State Street subway

A combination of conditions account for this unusual air flow, both as to quantity and direction. The most important of these is the fact that the three train stops in this area are so arranged that a train entering this section from either direction, north or south, travels at a higher rate of speed than when leaving it. For a considerable distance beyond the end of the platform, the incoming train continues at relatively high speed. Consequently, large volumes of air are pushed and pulled from the tubes into the open platform area by each incoming train. The movement of air continues even after the train comes to rest because of the velocity pressure of the air. Because of the berthing arrangements, a departing train, however, stops for passengers just before it enters the parallel tube section. Consequently, it blocks the air movement and largely annuls the effect of velocity pressure. Furthermore, when a departing train leaves the continuous platform section, it does not accelerate rapidly enough to produce an outward air movement equal to the inward movement on the opposite track until its rear end has passed the first blast relief shaft. As a result of these train movements, air is being constantly pumped into this downtown area. The only place it can escape is through the various station passageways.

Investigation of Effectiveness of Blast Shafts

As previously stated, blast shafts are connected to the train tubes beyond both ends of each of the station loading platforms. Their primary function is to relieve the piston action air blasts in stations, stairs and escalators and other public areas. These shafts, referred to as blast shafts, serve also as ventilating shafts. However, their close proximity to the stations, coupled with the fact that some of the outlying stations are colder in winter than the downtown stations, gave rise to the thought that unless it could be demonstrated that they actually accomplish a substantial reduction in air velocities throughout each station, it might be well to close the blast shafts during colder weather, and, in future subways, locate them farther from the station.

These possibilities were thoroughly investigated in a special study at the Chicago Avenue station. The arrangement of blast shafts at this station is typical of all outlying stations. In each of the two tubes, the approach and departure blast shaft areas total 200 sq ft and 100 sq ft, respectively, making an aggregate of 600 sq ft. These shafts were temporarily closed by placing heavy tarpaulins and planks over the sidewalk gratings. Air velocity readings were then taken for comparison with readings which had been taken before the shafts were closed. Simultaneously a record was made of

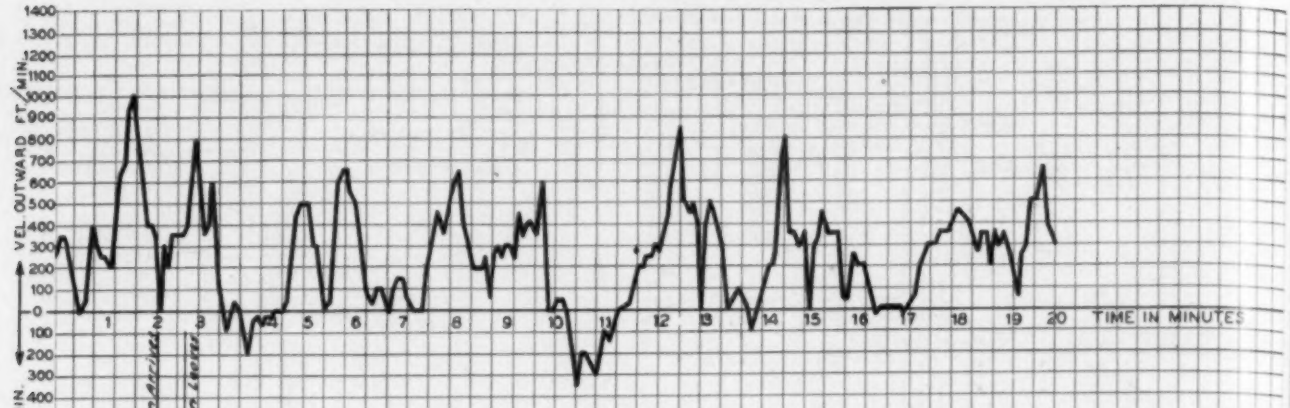

Fig. 5—Air velocities in Chicago Avenue station with blast shafts open

train movements in both tubes. The observed results were plotted to show graphically the effect of closing the blast shafts. Representative curves of *before and after* air velocities on escalators are shown in Figs. 5 and 6.

A comparison of these two curves brings out the following facts:

1. With the blast shafts closed, the reversals of direction and variations in magnitude of the air flow were far more numerous and violent than was the case when the blast shafts were open. Thus it is apparent that the closing of the blast shafts results in a great increase in the draftiness of a station.

2. During a 20-min period when the blast shafts were closed, there were 14 different occasions, totaling 5½ min, when the air velocity exceeded 600 fpm. In a similar period with the blast shafts open, this velocity was exceeded only seven times for a total of 1½-min.

The tests at Chicago Avenue station, and similar tests at Van Buren-Congress station, demonstrate that the blast shafts are effective in reducing air velocities in stair and escalator wells and in mezzanines. The tests also indicate that warming up of a station in winter cannot be accomplished by closing the blast shafts inasmuch as their closure would result in a very substantial increase in the amount of outside air that would be drawn into the subway by way of the mezzanine and stair and escalator wells. The net result would be a draftier and colder station.

Attention is called to the fact that these observations were made during a period when short trains were in operation and that higher and more prolonged velocity peaks occur with the longer trains running during the rush hour periods. Also the proposed fast accelerating new trains will further increase

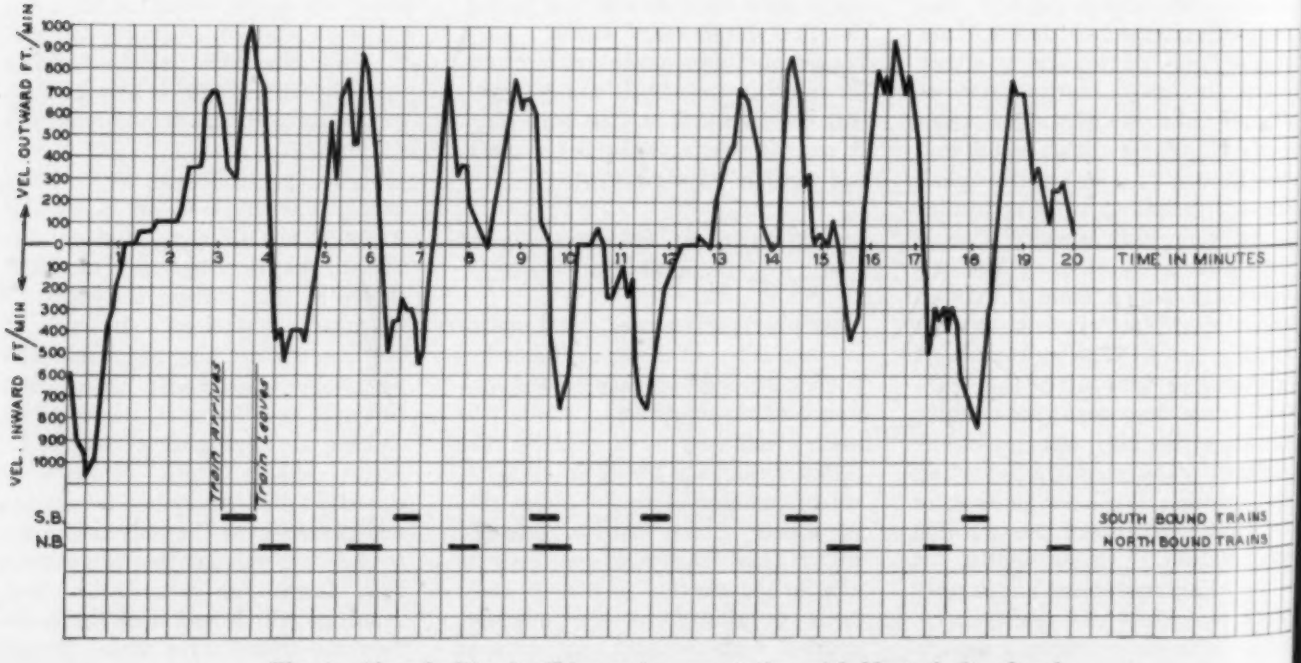

Fig. 6—Air velocities in Chicago Avenue station with blast shafts closed

these velocities so as to make the blast shafts even more essential.

Observation of Air Velocities in Train Tubes

So far we have been principally concerned with the comfort of the public and with atmospheric conditions within passenger station areas. However, in the training period prior to the opening of the subway to the public, special tests were conducted to determine if air velocities produced in the tubes by the trains were such as to represent a hazard to trackmen.

During these tests, air velocities approximately as anticipated were observed on the emergency walk and the trackmen's walk. Peak velocities were roughly equal to one-half of the train speed; for instance with a train at 38 mph (3,344 fpm), the air flow gradually rose to 1,600 fpm opposite the front of a train. It dropped to near zero during the four seconds required for the train to pass, jumped to 1,700 fpm opposite the rear of the train and then very gradually subsided. Had the vent louvers been open, the flow produced by the train would have been increased so that the volume would have been considerably greater than the net piston displacement of the train, or approximately as had been calculated prior to construction.

The highest velocities were found to take place in the 4 ft-6 in. wide by 7 ft-6 in. high access openings in the dividing wall between tubes. These are spaced at intervals of about 200 ft. At train speeds over 30 mph (or 2,640 fpm) these air velocities went beyond the 2,500 fpm limit of the velometer and were estimated to be the equivalent of train speed. These peaks occur as each train passes and are followed by a violent reversal in direction of air flow. It was realized that trains on the northbound and southbound tracks would occasionally be timed so as to greatly increase the unbalanced pressure. Since workmen instinctively take refuge in these openings, grab irons were installed as a safety precaution.

At each of the three side platform stations, there are 16 similar openings in the dividing wall between the tubes for the purpose of balancing pressures and limiting air velocities in escalator and stairwells. While not so effective in this respect as the open central platforms, they function better than anticipated. Peak velocities of 1,600 fpm through these openings are attained in spite of the fact that all trains come to a complete stop alongside of them.

Air velocities taken in the blast shafts adjacent to stations were found to vary widely at different points within the structure, particularly within the lower ports, and at the sidewalk grating. However, satisfactory metering conditions were found at a central location within the vertical shafts. With 4-car trains, either accelerating or decelerating because of the station stops, peak velocities in and out usually ranged between 500 and 700 fpm. While the average flow approached one-half of the maximum and continued in one direction or the other over 90 per cent of the time, the outward flow was very pronounced in the first shaft of a blast shaft unit. The last shaft in the group favored inward flow following passage of the train.

To date extensive meter readings in vent shafts have been deferred because the louvers were closed. Due to the higher train speeds opposite these vent shafts they should be more effective than the blast shafts. This is indicated by preliminary readings up to 1,000 fpm taken at the sidewalk level with the vent shaft louvers open. Such peaks are of brief duration, and there have been no reported instances of nuisances to pedestrians. The survey of air movement in these various groups of shafts is being continued for data to be used in future design. It is now evident, however, that both the blast shafts and the intermediate vent shafts are functioning as planned and that they will be effective in providing ventilation and in reducing air velocities resulting from train movements.

Subway Temperatures and Atmospheric Conditions

In designing the ventilation equipment and structures for the Chicago subways, the principal considerations were adequacy of capacity for heat disposal in summer and

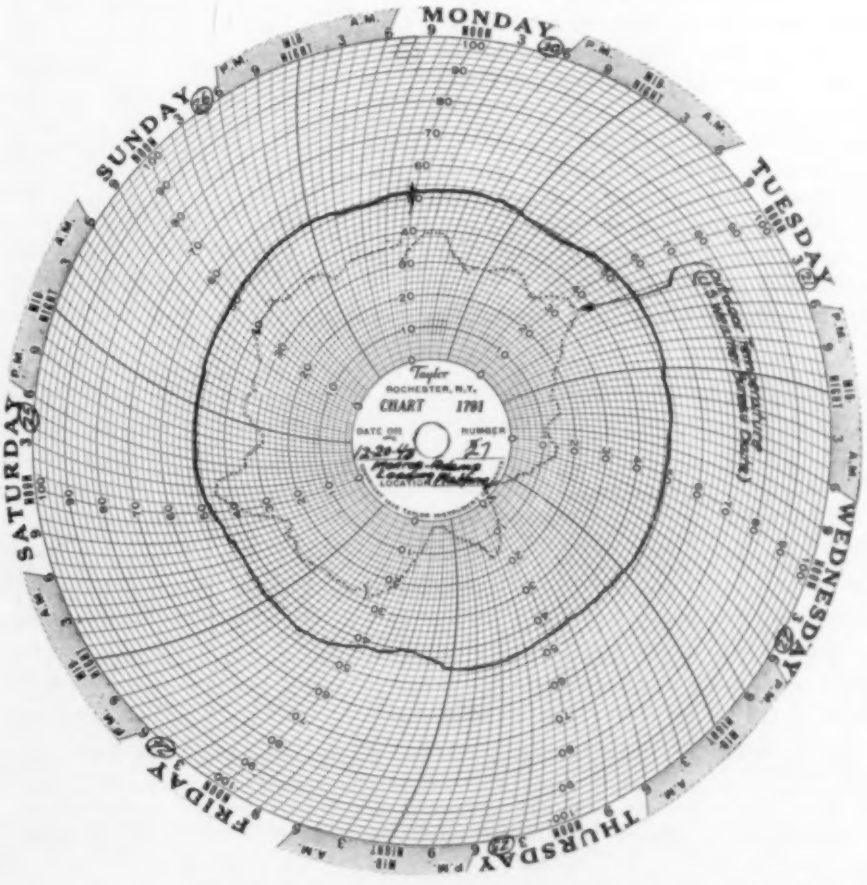

Fig. 7—Typical temperature recorder chart

the reduction of air velocities in public places. Each peak hour, 297 cars now pass a given point in State Street subway. The total cars per day is 2,980, giving 14,900 car miles for the 5 miles of 2-track route. Electrical energy in kilowatt hours per car mile for train propulsion and car heating is estimated at 4.15 in winter and 3.45 in summer, with a weighted annual average of 3.85. The mean consumption of 57,365 kw hours, multiplied by the thermal conversion factor (3413), gives a daily heat input of 196 million Btu per day. Additional electricity for subway lighting, equipment motors and space heaters, including emergency direct current service, reached a winter maximum of 16,000 kw hours per day. It will average 12,000 kw hours, or the equivalent of 41,000,000 Btu per day. Approximately 100,000 passengers enter the subway stations daily and an equal number enter or pass through the subway on trains. This is equivalent to 50,000 man hours per day at an average of 15 min per trip. Assuming 400 Btu body heat per man hour, there is a further addition of 20 million Btu per day. It will be noted that the present combined heat input of 257 million Btu per day is originating with trains averaging not closer than a 3 min headway. Facilities for the subway have been designed, however, for double the present traffic, and with trains operating on a 1½ min headway.

Little heat will permanently escape through the thick concrete walls and surrounding earth. The walls and earth act as a thermal accumulator of enormous capacity, absorbing heat in summer and returning it to the subway in winter with minor cycles of heat flow constantly taking place. The theoretical heat balance, previously mentioned,[8] included a determination of the probable production of heat, the accumulator effect of the concrete walls and the surrounding earth and a determination of the number of air changes required.

Fig. 7 is a thermometer record from the train platform at the Monroe-Adams station for a typical winter week. For purposes of comparison, hourly outdoor temperatures were also plotted on the chart. With outside sub-zero temperatures, the platform temperature dropped to 40 F. The usual winter temperature of this location was regular, however, and averaged 50 F. This approximates the mean annual Chicago temperature, as well as the temperature of the earth at platform depth. It is evident, then, that the concrete and the earth materially iron out wide fluctuations of temperature in the outside air drawn into the subway and are also most effective in leveling the temperature peaks which would otherwise occur during the periods of heavy traffic. This effect is somewhat less pronounced at locations where there is an air intake nearby because the cold air does not have time to become tempered by mixture and heat absorption from the surrounding walls and earth.

Fig. 8 is a chart of the mean daily temperatures for all train platform, mezzanine station and train tube locations in State Street subway at which recording thermometers are installed, with corresponding outdoor temperatures plotted for comparison. By partial fan operation during the summer of 1943, when this subway was being finished, the average temperature in the subway was raised to 10 deg above that in Dearborn Street subway where construction had been deferred and fans were not ready for operation. The temperature in the latter subway was frequently below the atmospheric dew point. Periods of heavy condensation resulted. Poor air circulation retarded evaporation and caused these periods of condensation to overlap. In the State Street subway, as a result of fan operation, prevailing temperatures during the final stages of construction were kept above the dew point. On infrequent occasions when some condensation occurred, it quickly dried, and did not interfere with the installation of equipment and station finish.

Between September 12, 1943, and October 17, 1943, trains were run in the State Street subway for instruction of crew men and other operating personnel. During this period both the subway temperature and the outdoor temperature averaged about 60 F, the partial train operation giving out sufficient heat to balance the cooling effect of the subway walls. For almost two months following October 17, 1943, at which time regular train operation started, a gradual decrease in outdoor temperatures was

[8]Loc. Cit., see Note 2.

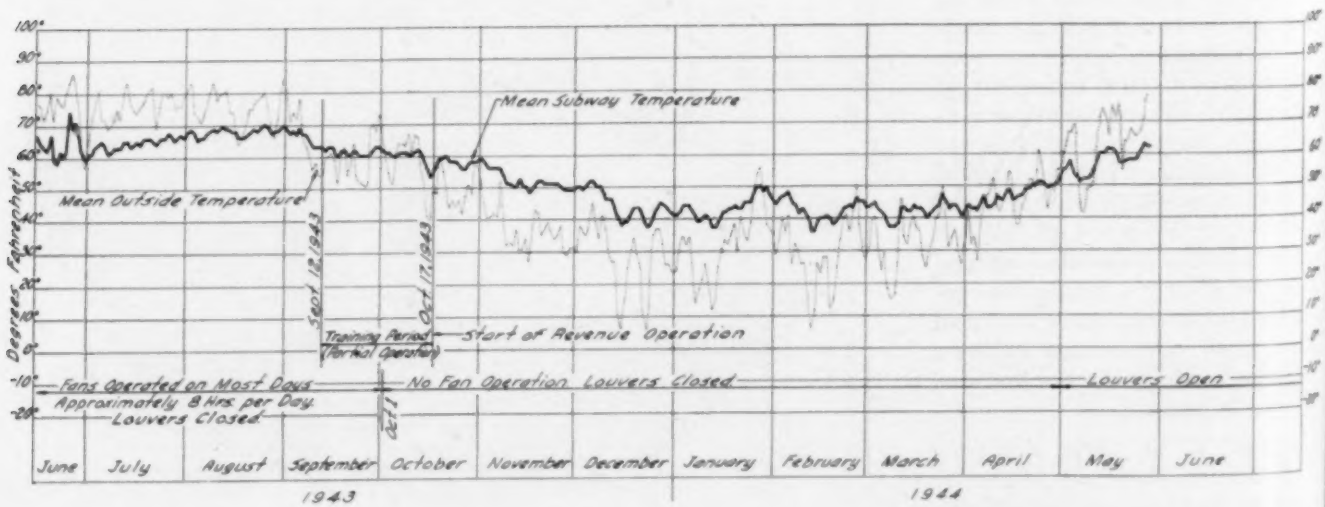

Fig. 8—Subway temperature chart—mean for entire subway

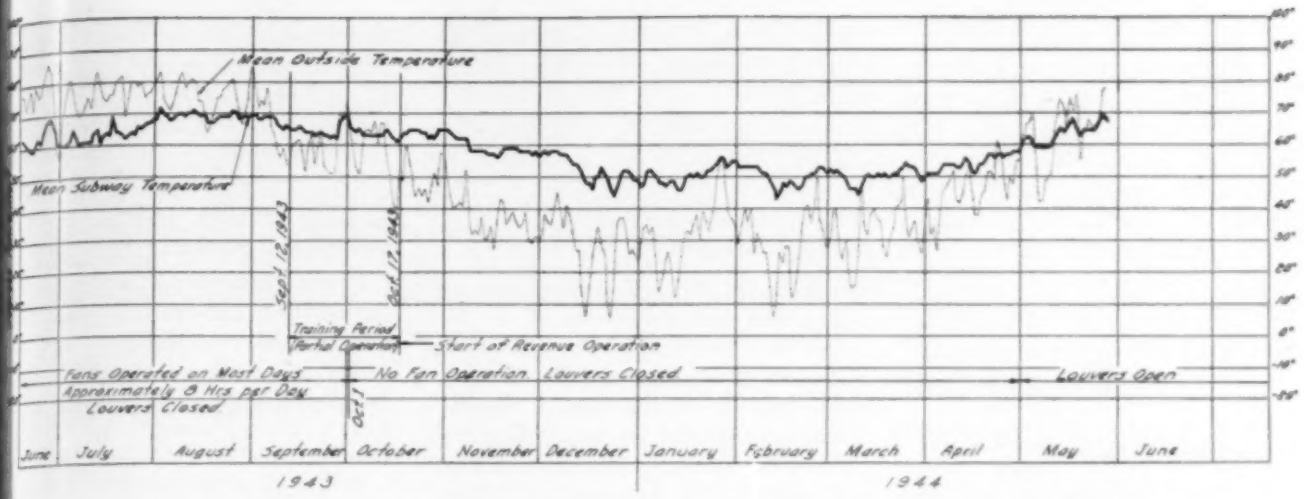
Mean Outside Temperature
Mean Subway Temperature
Sept 12 1943
Oct 17 1943
Training Period (Partial Operation)
Start of Revenue Operation
Fans Operated on Most Days Approximately 8 Hrs per Day Louvers Closed
No Fan Operation Louvers Closed
Louvers Open
June July August September October November December January February March April May June
1943
1944

Fig. 9—Subway temperature chart—mean for station platform at Monroe-Adams station

reflected in the subway by a more gradual decline to an average temperature of about 50 F.

Sub-zero temperatures in December were reflected by a pronounced drop in average subway temperature to the vicinity of 40 F, where it remained throughout the winter except for a rise to 50 F late in January, when unseasonably high outdoor temperatures prevailed. A comparatively balanced condition obtained in the subway throughout the winter, however, because the usual cold outdoor air was tempered to within 10 degrees of earth temperature by the heat given out by the walls and by the heat produced by car motors and other sources.

During spring months the subway will lag behind the rising outdoor temperatures and an occasional hot, humid day may cause the cooler subway air to reach the dew point. To guarantee against condensation, subway temperatures will be raised by remote control of louvers and by operation of fans, if necessary, so as to draw in hot air when available. When the outdoor temperature drops sharply, the louvers will be closed and the fans will be shut off to reduce the intake of cold air from the outside.

While the accumulator capacity of the concrete and earth is very great, the rate of heat flow and absorption is insufficient to dispose of the great quantity of heat which will be produced in the Chicago subways. The excess heat must be carried out of the subway by frequent air changes. Because of the frequent air changes effected by piston action, and by fan operation when necessary, a differential of only a few degrees between subway and normal outdoor temperatures will be sufficient to remove the excess heat and maintain comfortable temperatures within the subway.

Fig. 9 is a chart of mean daily temperatures at the Monroe-Adams station train platform. It is of interest in that it is typical of the uniform high winter temperatures prevailing in the important downtown stations due to the characteristic air flow previously discussed.

Fig. 10 is a similar chart for the Harrison Street station platform. It is selected because this station platform is the coldest in the State Street subway which is due to the fact that the prevailing flow of air in that vicinity is inward.

The predominant outward flow of tempered air through most of the station sidewalk entrances has been of value in preventing the accumulation of snow and ice on the steps. These entrances are not covered, but on three sides there is an open pipe railing mounted on a solid granite base 12 in. high. The pro-

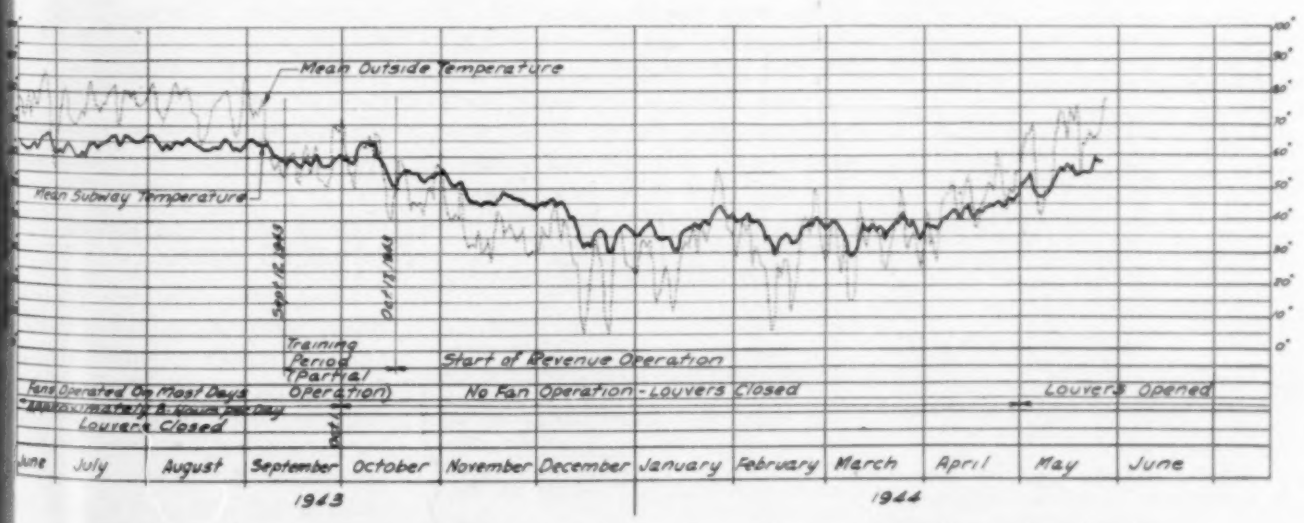
Mean Outside Temperature
Mean Subway Temperature
Sept 12 1943
Oct 17 1943
Training Period (Partial Operation)
Start of Revenue Operation
Fans Operated On Most Days Approximately 8 Hours per Day Louvers Closed
No Fan Operation - Louvers Closed
Louvers Opened
June July August September October November December January February March April May June
1943
1944

Fig. 10—Subway temperature chart—mean for station platform at Harrison Street Station

tection afforded by the granite base and the outward currents of warm air were sufficient during the recent winter to prevent snow from drifting in, even with heavy snow falls and high winds. Whatever snow fell on the steps usually melted quickly so that during the winter there were only a few occasions when a small amount of labor was required to free the outer steps of ice and snow.

Conclusions

Observations to date warrant the following conclusions:

1. Ventilation resulting from train piston action is providing the subway with fresh air far in excess of that required for breathing purposes, and, when supplemented by fan operation during hot periods, will be ample for heat removal even with ultimate traffic. This was the principal objective that was sought in designing the ventilation system.

2. Completion of the ventilation survey for the important downtown portion of State Street subway indicates a measured volume in excess of 400,000 cfm or the equivalent of 11 air changes per hour, due to train piston action within the 3,400 ft of route. All of this air does not come directly to this station section from out-of-doors since a considerable portion is admitted through the train tubes in which it is warmed on its way to the public areas. Such tempered air is preferable and gives increased comfort in winter.

3. The survey for the entire State Street subway has progressed sufficiently to indicate that, with trains operating on a 3-min headway, piston action is now supplying approximately 900,000 cfm of fresh outdoor air, or 4½ air changes per hour, and this rate will be increased during the warmer months to about 6 air changes by opening the remote controlled motor operated louvers at vent shafts. The Chicago subways were constructed to serve an ultimate traffic with trains having higher accelerating and braking power operating on a 1½ min headway. This will require greater ventilation for heat disposal but the necessary increase in air movement will automatically be produced with faster and more frequent trains.

4. Air velocities in public areas such as in escalator and stairwells, in mezzanine stations, at train platforms and through sidewalk gratings, seldom exceed an average of a few hundred feet per minute. Infrequent peaks up to 1,000 fpm are of short duration. No nuisances have been presented and the velocities do not exceed practical limits imposed by inherent subway conditions.

While air velocities in non-public places, such as within the train tubes, are relatively much greater no hazards are presented and they are approximately in accordance with design calculations.

5. Due to the characteristic flow of air toward the downtown stations and the predominating outward currents at street entrances, a uniform temperature averaging 50 F prevails in this important section in winter. At outlying stations the average winter temperature is approximately 10 deg lower.

6. The survey of ventilation and atmospheric conditions in State Street subway will be continued and extended to include Dearborn Street subway when the latter is placed in operation, the object being further to confirm conclusions so far drawn and to provide detail information to be used in future design.

WAR ON FUEL WASTE MUST GO ON

The war on fuel waste must go on, was the statement of S. H. Downs, President of the American Society of Heating and Ventilating Engineers, at the Grand Rapids meeting of the Society. Government agencies, he said, have freely predicted the next winter's fuel supplies will be short, coal production will be millions of tons behind demands, oil will not meet normal requirements for comfort, and gas supplies will be affected adversely. With this rather gloomy prediction in mind, Mr. Downs said it is necessary that every means of fuel conservation be applied in industry, in homes, and in every other plant where fuel is used for heat and power. He pointed out that at its meeting the Society commended and gave its wholehearted support to the National Fuel Efficiency Campaign, sponsored by the U. S. Bureau of Mines cooperating with other government agencies in the following resolution:

Be It Resolved, that the members of this Society pledge their support to the Government in its National Fuel Efficiency Program to expedite the war effort by helping to prevent the needless waste of heat and power.

Mr. Downs said that fuel conservation was vital to every person at the present time and urged that steps be taken to prepare heating equipment for winter service, so that every ton of coal will do 10 per cent more or the work of 2200 lb, that a 30 day oil supply will do 33 days' heating, and make every 1000 cu ft of gas do the work of 1100 cu ft. Effective utilization of the fuel is of prime importance so that the Society has prepared eleven major suggestions:

1. Recondition heating plant for winter service; 2. Maintain combustion efficiency; 3. Improve heat distribution system; 4. Control temperatures and avoid overheating; 5. Do not heat unused spaces; 6. Insulate hot water heater and piping; 7. Insulate walls and roofs; 8. Weatherstrip windows and doors; 9. Install storm windows and doors; 10. Fire available fuel properly; 11. Keep windows closed.

F. H. GAYLORD JOINS ECONOMY PUMPS

Frank H. Gaylord, a member of the ASHVE for over 23 years, has resigned as vice-president and director of Hoffman Specialty Co., Indianapolis, Ind., according to a recent announcement by Potter Bowles, president of the company.

In his association with Hoffman for nearly 25 years, in addition to

F. H. Gaylord

his duties as vice-president and director, Mr. Gaylord has served in an important sales capacity. For many years he made his headquarters in Chicago, directing sales activities on Hoffman products throughout the west, where he is well known to the wholesalers and the trade.

In leaving Hoffman, he takes with him the best wishes of all in the company who knew him intimately.

After September 1, Mr. Gaylord will be associated with Economy Pumps, Inc., Hamilton, Ohio, in the position of commercial vice-president, with headquarters in Chicago. Mr. Gaylord will direct the sales and promotion of Economy's new Wholesalers' Division.

STOKER MANUFACTURERS ESTABLISH CODES

After more than two years of study, conferences, and investigation, the stoker manufacturing industry, through the *Stoker Manufacturers' Association*, Chicago, Ill., has established two standard codes for the determination of rated capacities of both bituminous and anthracite underfeed stokers.

D. M. Myers

C. A. Fuller

H. B. Addington

CONSULTING ORGANIZATION

Announcement has been made that Orrok & Myers, consulting engineers, 21 East 40th St., New York (16), N. Y., since the passing of George A. Orrok, have reorganized for the continuance of their consulting practice in the field of industrial power and allied problems. The old name of Orrok & Myers will be continued with Myers, Fuller and Addington as successors, at the same address and with greatly expanded engineering facilities.

The senior member of the new organization is David Moffat Myers, consultant for over 30 years in the field of industrial power and who, for the past 13 years, was associated with George A. Orrok.

Charles A. Fuller, authority in heating, ventilating and air conditioning, formerly of the firm of Slocum & Fuller, and an associate of many years' standing, will be available for closer collaboration.

Herbert B. Addington, M.E., specialist in power plant design, who has been an associate on important projects for the past year and a half, has now become a member of the firm.

Mr. Myers has been active in several engineering societies and has contributed a number of papers to the ASHVE on fuel utilization and has served on its special committees.

Mr. Fuller became a Society member in 1913, has served on the Council and on many special committees, has contributed to the Transactions of the Society, and is the author of the well known text book on heating, ventilating and air conditioning, first published in 1914, and in a new form in 1938. He is a graduate of the University of Michigan with a degree of B.S. in mechanical engineering.

Mr. Addington has been an ASHVE member since 1938. He is a graduate of Purdue University and has specialized in the mechanical field in the design of equipment for all types of buildings.

Mr. Myers states that Walter D. Binger and Lester C. Hammond, under the name of Binger & Hammond, engineers, have joint offices with the new organization with which it is associated on active jobs involving factory building design and layout, as well as power plant studies and modernization.

These enlarged facilities have enabled the new firm to undertake comprehensive problems in the field of industry including studies and design of both steam and power problems, and heating and air conditioning as well as buildings and structures of all types.

NEW PERSONNEL AT PERFEX

Announcement has been made of recent changes in personnel at the Perfex Corp., Milwaukee, Wis.

C. E. Lewis, a member of the ASHVE for 15 years, is now vice-president and manager of the Controls Division. Mr. Lewis was formerly sales manager of the Delco Appliance Division, General Motors Corp., Rochester, N. Y., where he served for the past five years. He originally joined the Frigidaire Division of General Motors, later becoming air conditioning sales manager of Delco-Frigidaire.

C. E. Lewis

H. Dale Cook, a member of the ASHVE for a number of years, has also joined the Controls Division at Milwaukee as sales engineer. Mr. Cook was with the General Controls Company's Chicago office for the past five years, and previous to that he was associated with the Minneapolis-Honeywell Regulator Co., and with the Michigan Public Service Co.

FERGESTAD ESTABLISHES OWN FIRM

Marvin L. Fergestad, a member of the ASHVE for 10 years, has just announced the establishment of his own firm, Insulation Engineering Co., with offices at 1607 Hennepin Ave., Minneapolis 3, Minn. The firm will act as distributors and contractors for corkboard, balsam-wool fibre, with complete materials for building frozen food locker plants, and cold storage rooms of all kinds. The territory covered includes the entire Northwest.

HEATING SPECIALISTS ANNOUNCE NEW FIRM

A new firm to serve the metropolitan area in Chicago and Central Illinois has been organized by N. P. Fenner and Leo J. Potvin, to be known as Fenner & Potvin, with offices at 130 N. Wells St., Chicago 6, Ill. The firm will act as agents for Hoffman Specialty Co., Indianapolis, Ind.; Taco Heaters, Inc., New York, N. Y.; Lawler Automatic Controls, Mt. Vernon, N. Y.; Kenite Laboratory, Inc., New York, N. Y.; and Economy Pumps, Inc., Hamilton, Ohio.

Mr. Fenner has been a member of the ASHVE for a number of years and was formerly associated with Hoffman Specialty Co.

LECUREUX MANAGER AT FULLER-JONES

It has just been announced that E. Lecureux has been appointed manager of the Fuller-Jones Co., Florence, Ala., which recently opened offices for designing and consulting engineering work in the heating, ventilation, air conditioning and refrigeration field with facilities for post war needs. The

company is desirous of receiving literature, catalogs, data, etc., from manufacturers of equipment along these lines for their files.

He has been associated with the heating industry for the past 25 years, and has had several years' experience in the air conditioning field. He joined the ASHVE in 1943.

NEW *AIEE* PRESIDENT

C. A. Powel, manager of headquarters engineering, Westinghouse Electric and Manufacturing Co., Pittsburgh, Pa., was recently elected president of the *American Institute of Electrical Engineers* for the year beginning August 1944. Mr. Powel, in his acceptance speech at the meeting, pointed out that one of the major tasks facing the Institute during the coming year will be to aid in the education and eventual re-employment of the men who are released from the armed forces. Mr. Powel was born in Rouen, France, and educated in England and Switzerland. In 1919 he joined the General Engineering Department of Westinghouse at the East Pittsburgh, Pa., plant, specializing in power system engineering problems.

HEATING AND AIR CONDITIONING OF BUILDINGS

This is a British text* written by two English engineers, Messrs. Oscar Faber and J. R. Kell; the senior author, Dr. Faber, is president of the Institution of Heating and Ventilating Engineers. The second edition of this book, published in 1943, should prove interesting to many engineers on this side of the Atlantic.

Heating Systems: The authors have covered the entire field of heating and air conditioning rather completely. The one exception which American engineers will find to this statement is that there is not even a mention of residence warm air heating as we know it in this country. The various types of steam and hot water systems are described in detail, and examples are worked out to explain the design of each. A feature not commonly found in American texts is the large amount of cost data on various types of heating systems and equipment. Such data are based on prewar prices.

Radiant panel heating has been used much more extensively in England than in this country, and the authors have included a full discussion of the subject. Data on panel location, pipe spacing, water temperatures, recommended surface temperatures, heat emission from panels, etc., are given in convenient form. Many useful suggestions on installation are also included.

The authors devote an entire chapter to "Heating by High Pressure Hot Water," a subject that is entirely new to most engineers in this country. This system was developed on the continent and has been extensively adopted in Great Britain. It is particularly adapted to industrial installations where heating units may consist largely of finned surfaces and where heat may be needed for driers and other industrial purposes. Water temperatures of 300 F to 350 F are maintained, and boilers are operated at the saturation pressure corresponding to the temperature. A steam boiler of conventional design is used, and the proper pressure is maintained on the system by the steam pressure over the water. Pumps are used to circulate the water, and the authors state that the pipes for such a system, sized for 100 F temperature drop and a friction loss of 0.10 in. of water per foot of pipe, are the same as for steam at 150 lb per square inch gage sized for one pound per square inch loss per 100 ft of pipe. A detailed description is given of the ingenious piping connections to boilers and pumps, and of the types of safety and control specialties employed. A number of advantages are claimed for this type of system, among which are ease and accuracy of control, and operating economy.

Comfort Standards: The recommended inside design temperature for British homes and offices is only 65 F. However, these lower indoor temperatures are customary in Britain, not because of the effect of radiant heating, but because of acclimatization and the heavier clothing worn in Great Britain. The following paragraph from Chapter 2 should refute the misleading statements frequently found in advertising in this country, that where radiant panel heating is used, air temperatures may be 5 to 10 F lower than with other types of systems:

"Radiant heat in a closed cold room sooner or later raises the air temperature by warming the objects on which it falls, and they in turn warm the air by convection. The air temperature and radiant temperature will thus tend to approach one another, and probably the most comfortable condition exists when they are nearly equal, with the air slightly cooler than the mean radiant temperature. This condition is one in which the effect of radiation plays so little part that the reading of an ordinary thermometer is probably a safe standard of comparison, but it does not hold good if the radiation is from a high temperature source."

Air Conditioning: The modification of the ASHVE comfort chart to British comfort standards is also of interest. The authors present this chart with the comfort zone moved down so that the summer and winter comfort lines are at 67 and 62 ET, respectively, instead of 71 and 66 ET as used in this country.

The entire subject of air conditioning, including fans and other air handling equipment, is disposed of in two chapters which comprise approximately 20 per cent of the book. The need for summer air conditioning is not so self-evident in Great Britain as in this country because of the moderate summer conditions which prevail. The authors devote several pages to a discussion of the need and justification of summer cooling in different types of buildings having high internal loads.

A very abbreviated table of psychrometric data is included which at first glance seems to vary appreciably from the data used in this country. However, the British data are based on an atmospheric pressure of 29.5306 in. Hg. instead of our standard of 29.921 in. When the values are corrected for this pressure difference, the British data are in close agreement with our own. A small psychrometric chart, plotted from these data, is included in the text.

Clark M. Humphreys
ASHVE Research Laboratory
10700 *Euclid Avenue*
Cleveland 6, Ohio

*The Architectural Press, Cheam, Surrey, England, 45 shillings, pp. 580, 8 vo.

SUMMARY OF LOCAL CHAPTER MEETINGS

Chapter	Meeting Date	Subject	Speakers	Other Features	Attendance	Attendance Ratio*
Connecticut	June 1	Post War Planning	Dr. C.-E. A. Winslow, New Haven, 1st Vice-Pres. of ASHVE. Alfonso Herrera, Engr. from Chile, was introduced by Dr. Winslow	Pres. C. J. Lyons reported on chapter activities Treasurer's report submitted by J. R. Smak Tellers announced result of annual election, giving unanimous vote on slate given by Nominating Committee	48	1.5
North Texas	June 19	Origin, Fundamentals, Manufacture and Uses of Several Types of Synthetic Rubbers	C. L. Kribs, Jr., Consulting Engr., Dallas	Vice-Pres. E. T. Gessell appointed Committee to assemble data on existing State and Municipal Codes	44	1.1
	July 17	History of the Several Common Methods of Food Preservation	Prof. W. R. Woolrich, Dean of School of Engrg., University of Texas	Special welcome to C. L. Kribs, Jr., past president of chapter	48	1.2
Southern California	June 12	The Future Trends of Heating, Ventilating and Air Conditioning History of Blood Plasma	Dr. B. M. Woods, University of California B. M. Barnitz, American Red Cross	Art Theobald gave his final report as Treasurer	57	0.76
Wisconsin	May 15	The Society, Its Present and Future Ladies Night	S. H. Downs, Kalamazoo, Pres. of ASHVE	O. A. Trostel submitted his Treasurer's report H. K. Pride gave the report of the tellers	70	1.2

*The attendance ratios shown represent the meeting attendance divided by the Chapter membership. These will be useful as a partial indication of interest shown by local chapter members in various types of subjects programmed by other local chapters and may be helpful in deciding on subjects for other chapter meetings.

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the Journal of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 25 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by August 15, 1944, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
Crabbin, William W., Sheet Metal Worker, U. S. Coast Guard Yard (Navy), Curtis Bay, Md	Edwin Sternberg V. J. Cucci	W. E. Heibel D. G. Milligan
Crary, James O., Administrative Mgr., Higgins Industries, Inc., New Orleans, La.	L. V. Cressy G. E. May	T. H. Bean, Jr. J. S. Burke
Dahms, Alfred A., Dist. Mgr., Allis Chalmers Manufacturing Co., Kansas City, Mo.	L. T. Mart D. M. Allen	L. P. Heaven E. R. Ketchum
Erkin, Samuel G., Director of Research & Development, Grayson Heat Control, Ltd., Los Angeles, Calif. (*Advancement*)	James Holt G. B. Wilkes	A. A. Marks Art. Theobald
Izz-El-Din, Kamal, Carrier-Egypt, S.A.E., Cairo, Egypt. (*Advancement*)	M. V. Brakha M. E. Tahry	C. M. Ashley C. R. Harris

FARR, RICHARD S., Chief Engr., Farr Co., Los Angeles, Calif.

FETSCHER, JOHN J., Engr., George G. Sharp, Naval Archt., New York, N. Y.

GODBOLD, BERNARD P., Prin. Operating Engr., Smithsonian Institution, Washington, D. C.

GROSS, MORRIS H., Co-Owner, L. Rubin Co., Detroit, Mich.

HARTMAN, CHARLES W., Sales Engr., A. F. Hinrichsen, Inc., New York, N. Y.

KLINE, CLAYTON F., Vice-Pres., Nicholson, Inc., Durham, N. C.

KNIGHTON, JOHN K., Mgr., Air Cond. Div., Servel, Inc., Evansville, Ind.

KUTTLER, JOHN B., Asst. Chief Engr., Prudential Insurance Co. of America, Newark, N. J.

LOCKWOOD, JAMES R., Supervising Mech. Engr., Familian Pipe & Supply Co., South Gate, Calif.

LOWE, ROBERT A., Mech. Engr., U. S. Engineer Office, Los Angeles, Calif. (*Advancement*)

MATHANEY, EDGAR H., Snapper Sheet Metal Worker, U. S. Coast Guard Yard (Navy), Curtis Bay, Md.

NICHOLS, HOWARD R., Mech. Engr., Grudem Brothers Co., St. Paul, Minn. (*Advancement*)

PETERSON, JOHN E., Tech. Adviser, Minneapolis-Honeywell Regulator Co., Chicago, Ill.

ROSS, EARL F., Mech. Engr., W. C. Kruger, Architect, Santa Fe, N. M.

SCOTT, BERT, Departmental Engr., Sr., San Pedro Shipbuilding Div. of Western Pipe & Steel Co., San Pedro, Calif.

STILWELL, R. F., Fuel Engr., Red Jacket Coal Sales Co., Columbus, Ohio.

THEISS, ERNEST S., Instructor in Mech. Engrg., Duke University, Durham, N. C. (*Advancement*)

VANDERHOOF, AUSTIN L., Dist. Repr., Warren Webster & Co., Cleveland, Ohio. (*Advancement*)

WALSH, JOHN W., Pres. & Treas., John W. Walsh, Inc., Worcester, Mass.

WIBALDA, RAYMOND K., Asst. to Secy., J. J. Howden Co., Muskegon, Mich.

J. F. Park
J. L. Blake

V. J. Cucci
D. G. Milligan

S. P. Eagleton
S. L. Gregg

F. A. Lindsley
James Beattie

A. F. Hinrichsen
W. E. Heibel

W. M. Wallace, 2nd
Frederick J. Reed

W. F. Friend
A. E. Vroome

A. M. Greene, Jr.
Lee Nusbaum

J. S. Earhart
R. A. Lowe

W. O. Stewart
R. M. Storms

Edwin Sternberg
V. J. Cucci

R. E. Gorgen
F. C. Winterer

C. M. Burnam, Jr.
C. E. Price

J. H. McCabe
F. L. Adams

Leo Hungerford
R. A. Lowe

R. A. Sherman
R. B. Engdahl

E. R. Harding
F. J. Reed

G. L. Tuve
C. A. McKeeman

R. T. Kern
J. R. Bergan

T. D. Stafford
W. W. Bradfield

J. B. Griffith
Leo Hungerford

Edwin Sternberg
B. J. Steinke

F. A. Leser
Lester Maurer

W. G. Boales
F. X. Marzolf

R. A. Wasson
F. D. Lawrence

E. S. Theiss
Alton Skinner, Jr.

M. F. Blankin
C. F. Dietz

T. L. Thornton
Harold L. Alt

T. C. Caskey
J. F. Park

Leo Hungerford
Art. Theobald

W. E. Heibel
D. G. Milligan

William McNamara
J. A. Craig

J. S. Locke
J. F. Cummiskey

G. D. Maves
L. R. O'Rear

W. O. Stewart
Art. Theobald

A. I. Brown
D. H. Wyatt

W. M. Wallace, 2nd
C. Z. Adams

D. L. Taze
W. E. Eynon

W. G. Jennings
Carl W. Larson

F. C. Warren
L. A. Calcaterra

Candidates Elected

In the past issues of the Journal of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

ADAMS, GEORGE F., Engr., Midwest Plumbing & Heating Co., Denver, Colo.

CLAPPERTON, T. C., Vice-Pres., Michael Stuart Co., Ltd., Toronto, Ont., Canada.

DAHLSTROM, J. A., Head of Furnace Development Div., Perfection Stove Co., Cleveland, Ohio.

ERICKSON, HARRY H., Sales Engr., Haynes-Blankin Corp., Philadelphia, Pa. (*Advancement*)

FISCHER, CARL S., Sec'y-Treas., Fischer Heating & Plumbing Co., Memphis, Tenn.

FRANTZ, ADOLPH R., Service Mgr., Duo Therm Div. of Motor Wheel Corp., Lansing, Mich.

GERRISH, G. B., Asst. to Gen. Plant Mgr., Fitzgibbons Boiler Co., Inc., Oswego, N. Y. (*Advancement*)

GILMORE, JOHN L., Contractor, Brunswick, Ga. (*Advancement*)

HAMLET, F. AYLMER, Branch Office Mgr., C. A. Dunham Co., Ltd., Montreal, Que., Canada. (*Advancement*)

HARMONAY, WILLIAM L., Pres., Michael Harmonay Corp., Yonkers, N. Y. (*Advancement*)

MCCABE, JOHN H., Sales Mgr., American Blower Corp., Denver, Colo.

MILLER, NORTON R., Sales & Application Engr., The Trane Co., New York, N. Y.

MIZENER, RALPH S., Sales Engr., Parent & Kirkbride, Philadelphia, Pa.

MUSGRAVE, MERRILL N., Owner, Merrill N. Musgrave & Co., Seattle, Wash. (*Advancement*)

NORMAN, GEORGE C., Engr., Koithan & Johnson, Newark, N. J.

PERRY, M. ARTHUR, Supt. of Maintenance, DePauw University, Greencastle, Ind.

PURCELL, ROBERT E., Estimator & Sales Engr., Davis Bros., Detroit, Mich. (*Reinstatement*)

SEELBACH, HERMAN, JR., Dist. Mgr., Minneapolis-Honeywell Regulator Co., Buffalo, N. Y. (*Advancement*)

SMITH, CHARLES H., Sec'y, L. J. Wing Manufacturing Co., New York, N. Y.

SPARKS, JAMES D., Northwest Mgr., Ilg Electric Ventilating Co., Seattle, Wash. (*Advancement*)

STROTHER, WILLIAM E., U. S. Army Post Engr., Barge-Thompson Co., Atlanta, Ga. (*Advancement*)

UPDEGRAFF, LEE, Owner, Franklin Engineering Co., Los Angeles, Calif. (*Reinstatement and Advancement*)

YEOMANS, PAUL H., Sales Engr., Carrier Corp., Philadelphia, Pa. (*Reinstatement*)

ASSOCIATES

ADAMS, OCTAVIUS C., Sales Engr., The Meyer Furnace Co., New York, N. Y.

APPLEGATE, FRANCIS R., Plant Service Engr., Pratt & Whitney Aircraft Corp., Kansas City, Mo.

COCHRANE, WILLIAM, Air Cond. Engr., Federal Shipbuilding & Drydock Co., Newark, N. J.

DE VRIES, DON E., Engr., Nash-Kelvinator Corp., Grand Rapids, Mich.

EQUI, FERDINAND F., Owner, Stevens & Equi, Bridgeport, Conn.

HENEGAR, B. V., Owner, Southland Supply Co., Dallas, Texas.

HENSON, WENDELL L., Htg. & Vtg. Engr., Hughes Heating Co., Memphis, Tenn.

HORN, ARTEMUS J., Research & Designing Engr., Perfection Stove Co., Cleveland, Ohio.

HUGHES, CHARLES, Lt., Civil Engr., Naval Air Station, Millington, Tenn.

HUGHES, RALPH, Partner, Hughes Heating Co., Memphis, Tenn.

LAMMONS, JOHN B., American Radiator & Standard Sanitary Manufacturing Co., Memphis, Tenn.

LUSH, CLIFFORD N., Mech. Supt., Weston's Bread & Cake, Ltd., Winnipeg, Man., Canada.

MUNHALL, J. KENNETH, Indus. Htg. Engr., Edwin L. Wiegand Co., Buffalo, N. Y.

SHEARER, ARTHUR G., Mgr., Insulation Div., Hou-Tex Roofing Co., Houston, Texas.

SKINNER, FRANK, Supt., Barber Plumbing Co., Inc., Houston, Texas.

JUNIORS

BEISEL, KARL E., Asso. Naval Archt., Ventilation Sect., Norfolk Navy Yard, Portsmouth, Va.

KALLUSCH, HOWARD A., Precipitron Application Engr., Westinghouse Electric & Manufacturing Co., Cleveland, Ohio.

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One Year: W. A. DANIELSON, L. G. MILLER, A. E. STACEY, JR., B. M. WOODS, M. F. BLANKIN, G. L. TUVE. *Ex-Officio.*

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Nebraska	D. E. McCulley	B. G. Peterson
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Northern Ohio	L. S. Ries	John James
Oklahoma	E. T. P. Ellingson	
Ontario	V. J. Jenkinson	W. C. Kelly
Oregon	E. C. Willey	
Pacific Northwest	M. N. Musgrave	J. D. Sparks
Philadelphia	H. B. Hedges	Edwin Elliot
Pittsburgh	T. F. Rockwell	E. H. Riesmeyer, Jr.
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South Texas	J. A. Walsh	A. B. Banowsky
Southern California	Leo Hungerford	W. O. Stewart
Washington, D. C.	F. A. Leser	W. H. Littleford
Western Michigan	C. H. Pesterfield	J. W. Miller
Western New York	S. M. Quackenbush	S. W. Strouse
Wisconsin	A. S. Krenz	M. W. Bishop

Officers of Local Chapters

Atlanta: Organized, 1937. Headquarters, Atlanta, Ga. Meets, First Monday. President, M. M. Crout, 412 Houston St., N. E. Secretary, L. L. Barnes, 3995 N. Stratford Rd.

Cincinnati: Organized, 1932. Headquarters, Cincinnati, O. Meets, Second Tuesday. Honorary President, Capt. C. E. Hust. President, G. V. Sutfin, 1005-6 American Bldg., Cincinnati 2. Secretary, A. W. Edwards, 626 Broadway, Rm. 307, Cincinnati 2.

Connecticut: Organized, 1940. Headquarters, New Haven, Conn. President, L. A. Teasdale, 20 Ashmun St. Secretary, Winfield Roeder, 405 Temple St.

Delta: Organized, 1939. Headquarters, New Orleans, La. Meets, Second Tuesday. President, L. V. Cressy, 423 Baronne St., New Orleans 13. Secretary, J. S. Burke, 317 Baronne St., New Orleans 9.

Golden Gate: Organized, 1937. Headquarters, San Francisco, Calif. Meets, First Wednesday. President, C. L. Peterson, 2 Indian Rock Path, Berkeley. Secretary, James Gayner, 260 California St., San Francisco 11.

Illinois: Organized, 1906. Headquarters, Chicago, Ill. Meets, Second Monday. President, A. O. May, Room 925, 53 W. Jackson Blvd., Chicago 4. Secretary, C. M. Burnam, Jr., Room 1605, 6 N. Michigan Ave., Chicago 2.

Indiana: Organized, 1943. Headquarters, Indianapolis, Ind. Meets, Fourth Friday. President, W. C. Bevington, 730 Indiana Pythian Bldg. Secretary, C. W. Stewart, 1001 York St.

Iowa: Organized, 1940. Headquarters, Des Moines, Ia. Meets, Second Tuesday. President, W. W. Stuart, 417 9th St. Secretary, L. E. Hedeen, 1421 Bertch, Waterloo.

Kansas City: Organized, 1917. Headquarters, Kansas City, Mo. Meets, First Monday. President, D. M. Allen, 215 Pershing Rd., Kansas City 8. Secretary, R. E. Bade, 1102 Commerce Bldg.

Manitoba: Organized, 1935. Headquarters, Winnipeg, Man. Meets, Third Thursday. President, Einar Anderson, 152 Bannerman Ave. Secretary, F. T. Ball, 810 9th Ave., W., Calgary, Alta.

Massachusetts: Organized, 1912. Headquarters, Boston, Mass. Meets, Third Tuesday. President, D. M. Archer, 143 Federal St., Boston 10. Secretary, C. W. Larson, 184 Sycamore St., Roslindale.

Michigan: Organized, 1916. Headquarters, Detroit, Mich. Meets, First Monday after 10th of month. President, W. H. Old, 1761 Forest Ave. W., Detroit 8. Secretary, A. E. Knibb, 1003 Maryland Ave., Detroit 30.

Minnesota: Organized, 1918. Headquarters, Minneapolis, Minn. Meets, First Monday. President, F. W. Legler, 17 W. 28th St. Secretary, F. H. Schernbeck, 1067 10th Ave. S. E.

Montreal: Organized, 1936. Headquarters, Montreal, Que. Meets Third Monday. President, A. M. Peart, 637 Craig, W. Secretary, Leo Garneau, Room 832, Dominion Square Bldg.

Nebraska: Organized, 1940. Headquarters, Omaha. Meets, Second Tuesday. President, B. G. Peterson, 6235 Florence Blvd. Secretary, D. E. McCulley, 1101 Jackson St., Omaha 8.

New York: Organized, 1911. Headquarters, New York, N. Y. Meets, Third Monday. President, C. S. Koehler, 4274 Richardson Ave., New York 66. Secretary, Carl H. Flink, Room 3000, 51 Madison Ave., New York 10.

North Carolina: Organized, 1939. Headquarters, Durham, N. C. Meets, Quarterly. President, F. E. P. Klages, 1034 Jefferson Standard Bldg., Greensboro. Secretary, W. L. Hunken, 707 Guilford Bldg., Greensboro.

North Texas: Organized, 1938. Headquarters, Dallas, Tex. Meets, Third Monday. President, L. C. McClanahan, 603 Great National Life Bldg. Secretary, E. J. Stern, 701 Burt Bldg., Dallas 1.

Northern Ohio: Organized, 1916. Headquarters, Cleveland, O. Meets, Second Monday. President, D. L. Taze, 1302 Swetland Bldg., Cleveland 15. Secretary, R. H. Cutting, 3795 Glenwood Rd., Cleveland Heights.

Oklahoma: Organized, 1935. Headquarters, Oklahoma City, Okla. Meets, Second Monday. President, E. T. P. Ellingson, 314 Savings Bldg., Oklahoma City 2. Secretary, G. T. Donceel, Oklahoma Natural Gas Co.

Ontario: Organized, 1922. Headquarters, Toronto, Ont. Meets, First Monday. President, A. S. Morgan, 156 Glenmanor Dr. Secretary, H. R. Roth, 57 Bloor St., W.

Oregon: Organized, 1939. Headquarters, Portland, Ore. Meets, Thursday after First Tuesday. President, E. C. Willey, Oregon State College, Corvallis. Secretary, G. H. Risley, 516 S. W. Oak St., Portland 4.

Pacific Northwest: Organized, 1928. Headquarters, Seattle, Wash. Meets, Second Tuesday. President, M. N. Musgrave, 2019 Third Ave., Seattle 1. Secretary, J. D. Sparks, 7331 W. Green Lake Way, Seattle 3.

Philadelphia: Organized, 1916. Headquarters, Philadelphia, Pa. Meets, Second Thursday. President, A. C. Caldwell, 550 So. 48th St., Philadelphia 43. Secretary, J. O. Kirkbride, Fourth and Locust Sts., Philadelphia 6.

Pittsburgh: Organized, 1919. Headquarters, Pittsburgh, Pa. Meets, Second Monday. President, T. F. Rockwell, Carnegie Institute of Technology, Schenley Park. Secretary, E. H. Riesmeyer, Jr., 231-33 Water St., Pittsburgh 22.

St. Louis: Organized, 1918. Headquarters, St. Louis, Mo. Meets, First Tuesday. President, G. B. Rodenheiser, 4431 Finney Ave., St. Louis 13. Secretary, B. L. Evans, 571 Stratford Ave., University City.

South Texas: Organized, 1938. Headquarters, Houston, Texas. Meets, Third Friday. President, A. B. Banowsky, 3735 Ingold, Houston 5. Secretary, B. P. Fisher, Box 92, Houston 1.

Southern California: Organized, 1930. Headquarters, Los Angeles, Calif. Meets, Second Wednesday. President, Leo Hungerford, 3485 Wonderview Pl., Los Angeles 28. Secretary, Arthur Theobald, 336 North Foothill Rd., Beverly Hills, Calif.

Washington, D. C.: Organized, 1935. Headquarters, Washington, D. C. Meets, Second Wednesday. President, J. W. Markert, 8506 Garfield St., Bethesda, Md. Secretary, A. S. Gates, Jr., 111 County Rd., Kensington, Md.

Western Michigan: Organized, 1931. Headquarters, Grand Rapids, Mich. Meets, Second Monday. President, C. H. Pesterfield, Michigan State College, East Lansing. Secretary, V. H. Hill, 2111 Colvin Court, Lansing 10.

Western New York: Organized, 1919. Headquarters, Buffalo, N. Y. Meets, Second Monday. President, S. W. Strouse, 493 Franklin St., Buffalo 3. Secretary, G. E. Adema, 39 W. Balcom St.

Wisconsin: Organized, 1922. Headquarters, Milwaukee, Wis. Meets, Third Monday. President, I. J. Haus, 2880 N. Richards St., Milwaukee 1. Secretary, M. W. Bishop, 231 W. Wisconsin Ave., Milwaukee 2.

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*Member of Committee on Research.